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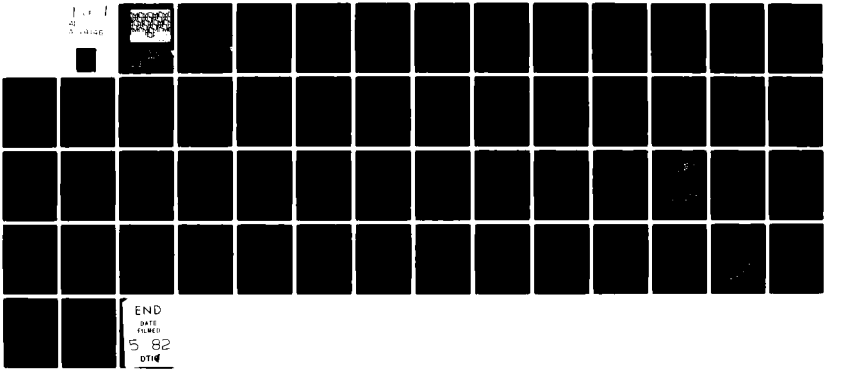

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ASSOCIATION OF SCIENTISTS AND ENGINEERS

IMPROVING THE NATIONAL SHIPBUILDING INDUSTRIAL BASE

R. RAMSAY

19TH ANNUAL TECHNICAL SYMPOSIUM 1982

ASSOCIATION OF SCIENTISTS AND ENGINEERS OF
THE NAVAL SEA SYSTEMS COMMAND
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AN OVERVIEW OF THE NATIONAL SHIPBUILDING INDUSTRIAL BASE

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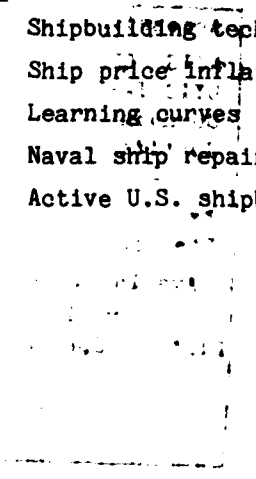

ABSTRACT

This paper provides an overview of the U.S. shipbuilding and repair industry vitality, and its past and present capability to support new ship construction programs in the national interest. The capabilities of the shipbuilding industrial base are also examined at the primary, secondary and tertiary levels of supplier support in relation to an expanded naval shipbuilding program.

The aspects of technological improvements and the humane use of human beings, in the ship production process, are discussed with particular reference to the workforce management practices in foreign countries.

An optimistic conclusion provides a prognosis regarding the prosecution of expanded naval shipbuilding programs within the capacity and capability of the U.S. industry.

FOREWORD

THE RENEWED NEED FOR AMERICAN INDUSTRY TECHNOLOGY LEADERSHIP IN

- o Marketing - International
- o Management - Personnel/Technical/Business
- o Research & Development
- o Manufacturing
- o Life-Cycle Logistic Support

The United States is not used to playing catch-up ball, though this is the economic game confronting the wavering industrial giant of today.

Almost since its founding, America set the industrial development pace for the rest of the world by advancing the technological state-of-the-art. However, in recent years, U.S. business enterprise has drifted to the sidelines in the face of government regulation, foreign infiltration of the national and international market place (with foreign government assistance), and declining worker productivity.

- o In 1965, 80 percent of the patents issued in the U.S. Patent Office originated in the U.S.; by 1977, that figure had slipped to 63 percent.

- o The U.S. lost 23 percent of its share of the overall world market in the 1970's (7 percent more than it lost in the preceding decade).

- o In 1950, the output of seven Japanese or three German workers was generally required to match that of a single American worker; today, only two Japanese or slightly more than one German match the productivity of one American.

- o Between 1950 and 1979, Japan increased manufacturing productivity by 974 percent; West Germany by 392 percent; the U.S. by a pallid 98 percent . . . or this could be construed as competitors striving to reach parity with the world leader.

- o In the last decade, federal funding to support basic research dropped 45 percent and in private industry, 12 percent.

These are samples of a declining record, encompassing shipbuilding and other industries, though this malaise should show signs of dissipation under the strategies of President Reagan's administration. The impetus is being generated on the premise that the fortunes of the United States lie in the free enterprise system, and that the fettered condition of industry by excessive government regulatory controls must be reduced. Given time, the business community is expected to respond as the administration's actions are implemented.

Vital to shipbuilding, and other industrial activities, is the U.S. steel industry which is faltering in the face of foreign imports and the lack of revitalization using new steel-making technologies. The average age of our steel industry equipment is 17 years old, with open-hearth furnaces approaching 33 years old. With steel, and other industries, an eagerness to retool is extant and foresightedly patient businessmen are pressuring

Congress for sizeable tax credits for income spent on research and development.

Tax relief via Congressional action is not incongruous with a free enterprise system approach though other countries may view this as a subsidy with public funds. In such instances, they fail to realize that it is in the national interest that a major U.S. Government responsibility is to create an incentivized atmosphere where industry can thrive in keeping with President Calvin Coolidge's (1923-1929) statement that the "Business of America is business." It is interesting to note that there are now similarities in strategy which exemplify the administrations of Presidents Coolidge and Reagan . . . "Implement economies in government operations, reduce taxation and provide aid to the private business sector without the burden of restrictive government regulation."

1. INTRODUCTION

The main stimulant which perpetuates the "military-industrial complex" is the widely-shared concensus that military superiority is the key to national security. Despite the inexorable dynamics of the arms race and the perverse beneficence of modern science; the multi-faceted weapons industry has experienced cyclic changes due to adjustments in national priorities and budget appropriations over the years.

In his farewell address, George Washington warned of the danger to liberty of "overgrown military establishments." Dwight D. Eisenhower resumed this theme in his final Presidential address on 17 January 1961 by stating:

> "This conjunction of an immense military establishment and a large arms industry is new to American experience. The total influence . . . economic, political, even spiritual is felt in every city, every statehouse, every office of the Federal Government. We recognize the imperative need for its development. Yet, we must not fail to comprehend its grave implications . . . In the councils of government, we must guard against the acquisition of unwarranted influence, whether sought or unsought, by the military-industrial complex. The potential for the disastrous rise of misplaced power exists and will persist."

There is little doubt that our visionary first President was speaking of national preparedness to counter adversarial forces other than those of the USSR, and it is highly probable that our thirty-third President could not predict the immensity of the present situation which overtly bespeaks the communist desire for world dominance. As a realist, President Eisenhower was more than aware of the payola, political logrolling, and sinister coalitions which could deplete the Federal treasury, through defense contracting largesse, as occurred in the aftermath of World War II and the Korean conflict. Today, stringent government controls, despite their cumbersome nature, are much to the fore and it now becomes of greater importance that we concentrate our focus on the specific line from his speech, "We recognize the imperative need for its (military/industrial) complex development." In his introspective way, as a World War II leader and a scholar of earlier military history, he also publically gave critical recognition to the merchant marine as the fourth arm of the U.S. military services, but, subsequently, the U.S. Merchant Marine has declined --with ensuing disasterous effects upon the domestic shipbuilding industry.

In retrospect (circa World World I), the enactment of laws to improve the pay and living conditions of American merchant seamen not only eliminated some of the poor shipboard and shoreside conditions, but progressively impacted competition with foreign shipping, as American ships increased their operating costs and sustained losses to Panamanian registry. For example, in 1948 and 1981, the monthly wages of able seamen under the United States flag, amounted to $226/1204 in comparison with the Canadian $170/1166; British $96/578; Greek $74/411; Danish $72/808; and Italian $34/399.

A special item of distinctive legislation, the Merchant Marine Act of 1936, was enacted when the American mercantile fleet was far behind that of other nations in size, speed and age. Congress wrote the Merchant Marine Act of 1936 to "foster the development and encourage the maintenance" of a merchant marine sufficient to carry its domestic and a substantial part of its foreign waterborne commerce, and to serve as a naval and military auxiliary in time of war or national emergency. This mercantile fleet was to be owned and operated by private United States citizens "insofar as practicable" and to be composed of the best equipped, safest and most suitable types of vessels constructed in the United States and manned with trained and efficient citizen personnel. The Act provided for the government payment of Construction Differential Subsidy (CDS) funds, up to a legal limit of 50 percent, to make up the difference between United States and foreign shipbuilding costs. These subsidies were to be repaid out of one-half of any profits in excess of 10 percent of the capital necessarily employed in the business.

Additionally, an Operational Differential Subsidy (ODS) was made available (average 75 percent) with magnitude determined by the demands on various competitive routes, together with government mortgage guarantees. Under the austere climate of present times, it appears that the Construction Differential Subsidy (CDS) will be either severely reduced or eliminated and the Operational Differential Subsidy (ODS) may be authorized for U.S. flag ships built overseas (McCloskey Amendment). Not only does this raise serious questions about the future of the U.S. mercantile marine, for use in a commercial mode and as a naval and military auxiliary, but it also casts doubt upon the survivability of the many U.S. shipyards which are running considerably below their capacity and capabilities at the present time.

We now have the benefit of 20/20 hindsight in assessing the present shortfalls of our complementary naval and mercantile fleets, in relation to the growth of adversarial naval seapower. We also recognize our over-reliance on foreign carriers who dominate the sea lanes of U.S. commerce. The present administration is to be commended in taking a much-needed first step in revitalizing our naval sea power and it is with optimism and trust that corresponding effects should be generated for revitalization of the U.S. mercantile marine . . . if its important strategic dual role be given Presidential recognition. This latter point is most important because this is yet another time in the history of the United States that recovery of military and commercial leadership must be enabled in a depressed national environment.

There are problems of inflationary pressures, limited capital investments, reliance on imported raw materials and energy sources, which are exacerbated by strained business-Government relations and adversarial management-labor negotiations.

The rising costs of ship production also cannot be disregarded. Recent Presidents seem to have assumed that the "military industrial complex" is continuing as a vigorous blue-chip asset in the American economy, though this could be an assumption worthy of closer scrutiny in view of the demands about to be imposed in the ship construction area.

2. POINTS IN SHIPBUILDING HISTORY

By not learning from the past, we are prone to make mistakes in the future, is a time-worn truism no matter what avenue of pursuit we choose to follow. The "boom and bust" cycle for the shipbuilding industry has been experienced internationally since the time of constructing Noah's non-military specification Ark. (In this unique project, it is known that his Supervisor of Shipbuilding was a Higher Power of unquestionable veracity, resulting in on-time completion, before the Flood, and an absence of contractor claims.)

Throughout time, shipbuilders have been recognized as great technology innovators in the production of ships to support the growth of maritime powers. In 1436, as Venice's maritime power grew, her citizens saw the need for an armed fleet to protect trade routes which were crucial to their livelihood. For a while, the city depended on private shipyards to build the military fleet and in times of crisis, she could draw ships from the commercial fleet. As her trading influence and concomitant need for protection grew, the city also made its own government shipyard, the Arsenal, operational to support fleet expansion programs . . . a parallel of our 1982 shipbuilding strategy? We can find many other parallels in the Arsenal of Venice which dignify the historical dynamism of the shipbuilding industry when given two vital ingredients: (1) A national need; (2) Appropriate incentives.

In this Venetian public shipyard, bookkeeping was just as important as it was in the private sector, but with a somewhat different methodology. The supervisors were personally directed to handle and record the use of appropriations, but by the middle of the 15th century, bookkeepers and pages were hired for this purpose. In an attempt at increased efficiency, the shipyard kept a strict accounting of monies, materials and manpower. An early form of cost accounting was also used.

All accounts were consolidated into two journals and one ledger, with one set of the journals kept by the Lords of Arsenal for comparison with the ledger (an early use of double-entry bookkeeping). Three types of expense accounts were recognized: fixed, variable and extraordinary. A meticulous record was also kept of everything that entered and left the shipyard.

In the 16th century, when the Venetian State and Navy were at their zenith of power, methods of large-scale production were needed to build the warships and maintain the reserve fleet. The Arsenal of Venice, as a consequence, became what was perhaps the largest industrial plant in the world. It covered 60 acres of ground and water and employed up to 2000 workers. Many of the solutions to problems created by size (accounting, material handling and workforce management) were handled in a manner very similar to that used today.

The management of the Arsenal public shipyard was well noted for its checks and balances. Although three Lords of the Arsenal were officially in charge, the Commissioners, who were the connecting link between the Venetian Senate and the Arsenal, also had influences. The Senate itself often managed or interfered with the management of the Arsenal. The Commissioners and Lords were so closely involved in the financial management,

purchasing and similar functions that they were unable to direct the actual shipbuilding; foremen and technical advisors headed the large operating divisions and it became evident that the work of the Arsenal was so vital to the future of Venice that no one man or group was alone trusted to manage the complex. Is not the present an echo of the past?

The Arsenal did more than build ships. In fact, it had a three-fold purpose: (1) the manufacture of ships (about 106 feet in length), arms and equipment; (2) the storage of the equipment until needed; and (3) the assembly and refitting of the ships on reserve.

Several management practices are worthy of note: (1) the numbering and warehousing of finished parts; (2) assembly-line outfitting of the ships; (3) employee relations; (4) standardization of parts; (5) financial accounting controls; (6) inventory control; and (7) manufacturing cost control. All of these should sound familiar since they reflect similar thought processes and actions of 1982 shipyard management throughout the world. We cannot dispute their Venetian management acumen, no matter which element we care to critique.

Manufacturing - The planned sequential production flow of materials, with assigned responsibility and delegated authority to managers and tradesmen, resulted in an efficient plant with maximum worker motivation. In outfitting ships, the ships were towed to various warehouses along a canal (bringing the ship to the equipment vice the equipment to the ship) . . . a series-production methodology which antedates the claims of Henry Ford by a wide margin, and shows the potential of technology tansfer to an industry unrelated in time or product

Warehousing - Enabled material to be prepositioned in type, quantity, quality and location to support large scale production. The effectiveness of this operation being contingent upon the capacity of the national industrial base.

As we progress to recent times, the United States industry can look with pride upon its accomplishments as a contemporary shipbuilding arsenal during two World Wars. In World War II, a combination of limited government regulation and uninhibited private enterprise, within a strikingly decentralized kind of administered economy, pervaded American industry. In shipbuilding, all the major problems of production . . . management, labor supply, capital and materials . . . were jointly tackled by private corporations and government agencies. Both acted to draw managerial talent from other fields of activity. Both placed orders for materials, equipment and components. Both campaigned to draw one million to the labor force in the shipyards and, by joint action, they created the conditions that made the workers want to join the shipbuilding force. Consequently, the achievement of U.S. shipbuilding in World War II endures as a milestone of

private enterprise and government cooperation which is repeatable today if: (1) a national need is expressed; and (2) adequate incentives are offered.

As in the case of the Arsenal of Venice, motivation and creativity came to the forefront in the U.S. shipbuilding industry during a time of national mobilization.

Shipyards were laid out for multiple production using straight-line flow and turning-flow layouts (figure 2); the Defoe Shipyard at Bay City, Michigan introduced the "roll over" ship construction technique to maximize the use of down-hand welding with smooth production flow; modular construction external to the building berths was practiced widely --resulting in the mass production of surface ships never heretofore equalled. At one point during World War II, Electric Boat launched a submarine within two weeks of keel-laying. Some background data are provided by figures 3 and 4.

Many 'stunt' ships received additional preassembly off the building ways and by special concentrations of manpower, materials and yard services; this resulted in phenomenally low "keel-laying" to launching times; as low as 10 days for Liberty ships. In one case, Richmond No. 2 responded by assembling a ship in only 4 days on the ways. These were called 'stunt' ships because they were sensational achievements, arousing talk and focusing attention on astute management, new methods, improved training, etc., which collectively heightened workforce and public morale. The yards made no attempt to keep up any such pace as 4 days on the building ways; 17 days on the ways was a more representative norm.

International cooperation and technology transfer should be given due recognition as contributors to the success of these shipbuilding achievements. In the early part of World War II, the U.S. shipyard expansion program commenced in response to British Merchant Shipping Mission initiatives. These accomplishments were far exceeded by the U.S. Maritime Commission shipbuilding program which came later. The British Mission gave contracts for the construction of two yards, each yard with a contract to build 30 identical ships - 11 knots, 10,000-ton freighters. The design of this ship was that of a North-East Coast (England) yard and the ideas and methods adopted in these two yards at Richmond and Portland were also British. The record shows that the Richmond yard delivered its 30 ships within 19 months of contract signing and Portland was well within the contract period of performance. These extraordinary efforts were subsequently surpassed by the U.S. shipbuilding program when 27 million tons of freighters and tankers were launched between 1942-1943. In 1943, 1238 Liberty ships were delivered from 14 U.S. yards. The success of the U.S. program depended on the standardization of production, with speed coming from production continuity, which enhanced the ability to learn from experience. Usually, the second round of ships was launched in about half the time and the tenth round in one-fifth the time of the first ship (figures 5 and 6).

With this brief address of shipbuilding historical points, there is adequate evidence to dispel the negative charisma usually propagated by the U.S. news media, which would falsely portray the U.S. shipbuilding industry as laggardly in technology developments, uninspiring in the talent it attracts and an industrial dinosaur.

The building of ships is an industry which has grown out of traditional crafts. It has in the past adapted itself to changing technology requirements and possibilities, and to changes of general economic and commercial conditions. There is still much conflict as to whether shipbuilding is a craft or an engineering industry. Both inside and outside the industry, there are many who feel that ships and their constructors have a unique romantic value unto themselves which could account for a "hasten slowly" investor approach to the acceptance of new technologies. There may even be grounds for hearkening to some shipbuilding veterans who astutely observe that better tools will never correct the deficiencies of bad workmen, and may possibly worsen conditions. The same cadre is also cautious in the acceptance of technology which they say could result in an electronically assisted production demise, equivalent to the radar assisted aircraft collision and the computer-aided business bankruptcy. However, there is cause for optimism in the shipbuilding community if technological moderation is observed and a national need, with incentives, become dominant.

3. U.S. SHIPBUILDING STATUS BRIEF

At the risk of being repetitive, the U.S. shipbuilding status should always be represented with full recognition of the need for complementary naval and mercantile fleet construction in the national interest. The major importance of the mercantile marine for naval purposes has been, and will be, in furnishing non-combatant ships for vital support service functions.

The United States, for instance, discovered its grave lack of colliers at an earlier date, when the "Great White Fleet" made its world cruise in 1907-1909. With the shift to oil-fired ships soon afterwards, fast tankers became indispensable fleet auxiliaries in the major navies of the world. In two World Wars, some merchant liners were commissioned for patrol or raiding missions, but these were of minor overall importance. Fast liners likewise became indispensable as transports, while large numbers of freighters were needed to carry munitions, food, and supplies to distant theaters of war.

These auxiliary roles explain the continuing military concern in the mercantile marines' weakened sealift capability for the supply support of naval combatants and rapid troop deployments. A Department of Defense initiative in 1965-1966 failed to gain Congressional support for the Fast Deployment Logistic Ship (FDLS) concept and now that the T-AKRX concept for Rapid Deployment Force enablement is active, the U.S. has purchased six SL-7 containerships, with further option for two more, from Sea-Land Industries for $207.5 million. These ships will enable the transportation of supplies, located within CONUS, to potential danger areas worldwide.These ships are large (946 feet x 105.5 feet), extremely fast (33 knots) and were originally designed to carry 1,968 containers. Within three years, they will be converted to self-sustaining roll-on/roll-off vessels with sufficient cranes, booms, hatches, and sideports to permit rapid loading and unloading. When converted, the eight SL-7s will have the capability to carry all the equipment required by a heavy mechanized Army division. While the Army will be the principal user of the SL-7s, to be designated T-AKRXs, they will be equally capable of transporting Air Force, Marine Corps, or Navy equipment and supplies when necessary.

While this SL-7 conversion work will bring a small measure of relief to the U.S. shipbuilding industry, it falls far short of absorbing the underutilized capacity now extant. The overall American industry operates in a free-market economy and the ultimate structure of the nation's military and commercial ship procurement base is grounded in the structure, conduct and performance of our domestic shipbuilding industry. Also, lest we forget, the U.S. shipbuilders are charged with the design and construction of durable ocean-going products whose characteristics combine the qualities least attractive to private investment in a high-wage, advanced technology, mature industrial nation operating in a fiscal environment which threatens the continuance of government subsidies -- while other lesser-developed countries increasingly underwrite shipbuilding industries considered as national assets. The direct impact of government supportive subsidies and attractive credit terms, in international market place competition, has had its effect as we note the rise of Japanese and Korean shipbuilders to positions of world dominance . . . at the expense of other established shipbuilding countries.

An analysis of the ailing British shipbuilding industry was made by the Geddes Report (circa 1966) with incisive findings which may have direct relevance to the presently underutilized U.S. shipbuilding industry. Key points of the report addressed the anatomy of shipbuilding competitiveness as a function of the objectives and policies laid down by company Directors, and the ability of the executive management to achieve the objectives by implementing their policies. This cannot be done unless the right people are recruited, trained and employed to carry out their roles in an appropriate and well-defined organizational structure.

A major objective addressed the competitiveness of the shipbuilders' products; i.e., the ability to deliver the right product, at the right price, at the right time. The factors on which this depends are listed below under that element of competitiveness which they will primarily affect.

(see over)

FACTORS OF COMPETITION

Management Controlled	External Variables

THE RIGHT PRODUCT

(A product of the type, size, design and quality for which there is demand)

Market research	Market preference by ship type
Sales Promotion	Stability of world demand
Use of customers' operating experience	Technology consciousness of suppliers and sub-contractors
Technological state-of-the-art	
Design rationale	
Planning of productive facilities	
Quality control ensuring accurate individual work	

THE RIGHT PRICE

(A price that is competitive and provides the manufacturer with a reasonable margin of profit)

Selective contracting	Stability of currency*
Accurate estimating	Degree of unfair competition*
Production technology development	Reasonableness of credit terms*
Investment in economical productive facilities	Competitiveness and predictability of suppliers and sub-contractors
Intensive use of available resources	Labor contract stability
Good labor/management relations and the motivation of skilled workers	
Value engineering	
Cost control	
Good commercial relations with suppliers and sub-contractors	

THE RIGHT TIME

(A delivery date that meets the requirements of potential customers and is achieved)

Planning and allocation of resources	Availability of good credit terms*
Production control and progressing	Availability of human resources
Investment in time-saving capital assets	Timely deliveries from reliable suppliers and sub-contractors
Good labor/management relations and the motivation of skilled workers	Absence of undue owners' modifications
Influence on suppliers and sub-contractors	

* Government/Private Business coalition required.

The immediate issues for the underutilized U.S. shipbuilding industry are those of survivability and contraction rather than capacity or technical credibility. The horizontal structure of the U.S. shipbuilding industry is characterized by oligopoly, a term used by economists to refer to industries dominated by a few large firms. Figure 7 reflects the industry's dominance by 25 major shipyards owned by 20 firms (43 percent of all shipbuilding and repair firms). These 25 yards are shown in figure 8.

The risk when engaging in naval or merchant ship construction from 1954 to 1979 is exemplified by figure 9, with its erratic peaks and valleys in the ship ordering profile. Complementary to this risk, the economics of ship construction plants should also be understood. One significant indicator could be the ASSET/SALES ratio to mirror the "nature of the business"; this is a measure of how many dollars of business can be generated by one dollar of assets. This ratio is influenced by the technological state-of-the-art required to execute a ship construction or repair program.

As a baseline of understanding, a 1:10 ratio is representative of a low-technology investment and conversely, a 10:1 ratio is indicative of high-technology investment. It is reported that the overall European (NATO) defense-related industries approximate a ratio of 1:1; the average of the overall U.S. defense-related industry approximates a ratio of 1:2; for commercial shipbuilding 1:4 and for commercial ship overhaul and repair 1:10. Apart from the low-technology investment of the latter, the workload stability, simplified contracting and higher profit margins contribute to the ship repair business attractiveness. More firms may be expected to convert to this field rather than become defunct in the present business environment.

The ship repair and overhaul industrial base of the United States is supported by the military and commercial ship operating sectors and show the greater profitability . . . sometimes in the range of 20 to 30 percent, though specific data are difficult to retrieve because of:

- o Detailed data for business profits are company confidential.
- o Many small companies, doing repair and overhaul only, do not publish an annual report for the public.
- o Independent shipyards, who publish an annual report, do not break out the profit of repair from other profits.
- o Conglomerates who own shipyards do not break them out as profit centers . . . especially the repair portion of their work.

However, it should be noted that 35 percent of this commercial ship repair and overhaul business is attributable to foreign accounts, thus reflecting on the international competitiveness of the U.S. industry with respect to cost, performance and schedule.

In 1981, a total of 125 companies were engaged in commercial ship repair and overhaul work, employing about 50,000 workers. Of these 125 companies, only 30 shipyards had a capacity to build and overhaul ships over 475 feet in length. Of these 30 shipyards, 8 shipyards were primarily repair yards:

Bethlehem Shipbuilding Co. San Francisco	- Pacific Coast
Maryland Shipbuilding and Drydock Co.	- Atlantic Coast
Norfolk Shipbuilding Co.	- Atlantic Coast
Sun Shipbuilding and Drydock	- Atlantic Coast
Tampa Shipbuilding Co.	- Gulf Coast
Todd Shipyards - Galveston	- Gulf Coast
Todd Shipyards - Houston	- Gulf Coast
Alabama Drydock and Shipbuilding Co.	- Gulf Coast

At least eight elements are identifiable as contributory to the greater profitability of commercial ship overhaul and repair in the U.S. industry.

The Workload Stable and predictable in the long-term. (Figure 10)

The Geographical Location Shipyards to be profitable in the commercial repair business must be located on shipping routes with great traffic concentration and with capability to service the ship types and sizes operating on these routes. Intensive trade centers are presently: (1) San Francisco - Seattle region for general cargo on Alaska routes; (2) Gulf region for world-wide oil routes; and (3) the Norfolk-Boston region servicing world-wide bulk and general cargo routes.

The Labor Force Labor force skill levels are generally less demanding for commercial work than for the complex, military warships. Commercial ship repair and overhaul work is labor intensive, and labor force stability is commensurate with the stable market. Training and retraining is minimized.

Subcontractor Support Commercial ship repair and overhaul activities enjoy great autonomy with rigorous internal control a key factor. Subcontracting of work sometimes accounts for less than 10 percent of a work package (i.e., the yard performs 90 percent of a work package, thereby maximizing the use of labor force and capital investment). The internal control associated with autonomy reduces financial risk, dependence on subcontractor's delivery schedules and the quality of subcontractor products which could degrade the overall performance.

Technology In commercial ship repair and overhaul operations, success is dependent upon skilled artisans using basic handtools. Power assists and other equipment are usually simple and reliable. Hence, the capital investment for technology in this labor-intensive industry is usually low.

Type and Scope of Work Commercial repair and overhaul work packages are normally non-complex, well-scoped, effectively managed, and usually of short duration. Since at-sea time is of highest importance to the commercial ship operator, overtime rates, up to quadruple, may be paid for 24-hour services.

Controlling Procedures Commercial repair and overhaul practices represent the epitome of management and worker accountability. On-site decisions are made by all levels of management in conjunction with approval by the representative from either the owner, the Classification Society or equipment manufacturers, as appropriate.

These commercial relationships approach a true partnership where the repair/overhaul activity recognizes contractual obligations and the owner limits his expectations to the contract scope. Such contracts may range from multiple-page specifications (2-5 pages of work items) to a simple handshake on small jobs.

Cash-Flow In the commercial repair and overhaul workplace, this is usually a non-problem. The normal payment is upon satisfactory work completion and problems are rare especially when steady clients to certain activities develop a personalized working relationship. For "casual customers", repair and overhaul activities have access to financial information services which rapidly retrieve the information necessary to establish an ability to meet financial commitments. Furthermore, each individual repair and overhaul job is only a small fraction of the annual business and, hence, the shipyard's financial risk associated with each individual job is extremely low. Since few jobs take longer than one week, progress payments and related cash-flow problems do not exist.

In the overview, the profitability of the commercial ship repair and overhaul industry has long-standing merit, with many unique features inapplicable to the technical complexities of warships and their extended periods of availability during peace-time conditions.

Rather than become preoccupied with the capacity of primary level shipbuilding and repair plants, it is important that the soundness of the secondary and tertiary-levels of suppliers in the national industrial base be given due consideration. It should be noted that figure 11 shows that a considerable part of a new ship cost is represented by the value added by the builder. It also indicates that the U.S. shipbuilder, operating in a non-vertically integrated industry, is dependent on a wide variety of external industries, not only as a marginal customer, but for relatively small fractions of their total products. This results in protracted material delivery lead times with attendant disruption and delay in construction schedules. Shipbuilding is not a position to command rapid responses by suppliers unless government intervention, using provisions of the Defense Production Act of 1950, are invoked. When estimating a surge-demand reaction, in response to a rapidly expanding naval construction program, more concern should be manifested in the supplier area than in the assessment of shipyard building ways availability.

Concern is well-justified, though not confined in focus to the depleted U.S. base of shipbuilding support firms, when compared with the population of counterpart European and Japanese firms shown in figure 12. As one can see, the U.S. firms supporting the shipbuilding industry are, on the whole, a minority in a world-wide industry. A principal exception is in the gas and steam turbine generator industry -- which supplies on-shore power generation plants as well as shipbuilders. The listings, of course, do not represent a census of industry; they only reflect an interest in international sales by the listed firms.

Of major concern is the greatly reduced U.S. foundry industry which has repeatably sought curtailment of overseas procurements. In October 1980, it was reported that only 30 percent of the U.S. forging industry labor hours were being used for military forgings, of which

aerospace space products accounted for 75 percent (i.e., shipbuilding became less than 8 percent (0.25 x 0.30)). However, the elasticity in the supplier industry cannot be underestimated. Given an increased order book, many suppliers have indicated that lead times could be reduced, and plant expansion would be viable despite the present unfavorable terms of financing. Such a response supports the universal truism that market-oriented private businesses will certainly respond, with alacrity, to their largest customers. A recent NAVSHIPSO survey of 543 suppliers to the shipbuilding industry revealed the following:

CAPACITY

1. The average manufacturer is working to 70% capacity
2. 13% are working to 90% capacity or higher
3. 78% are working between 50% and 90% capacity
4. 9% are working below 50% capacity

INVOLVEMENT

1. 81% are supporting the marine industry
2. 71% are directly supporting Navy shipbuilding
3. 55% desire Navy work or additional Navy work

SALES

1. 62% have experienced sales growth in 1980
2. 70% forecast an increase in sales during 1981
3. 12% forecast a decrease in sales during 1981

EXPANSION

1. 74% plan to expand during the next five years
2. 17% do not plan to expand during the next five years

PROBLEMS

1. 13% claimed to have problems because of government regulation
2. 29% reported shortages of skilled manpower (mostly machinists)
3. 40% reported problems with long-lead time raw material, semi-finished components or finished components

The present status of the U.S. shipbuilding and repair industry displays a picture of over-capacity in shipyard plants (except for nuclear-powered ships) and a decreasing base of supplier support. The construction of military ships, especially for the expanded U.S. Navy, will provide a measure of longer-term work for a limited number of qualified shipyards. It is predicted that the commercial and military repair overhaul/inspection business will retain its stability for a wide variety of work, since not all of the nationwide shipyard assets may diversify into oil-rig and industrial construction, even if the administration authorizes additional oil production programs (offshore and land-based). The situation for the overall marine industry could be viewed as critical, but not terminal. Realignment and closures will occur, similar to these occurring in the U.S. automobile industry and the international shipbuilding industry. The future may be forecast with Darwinian surety as the competitive forces of

the free enterprise system gather impetus to eliminate the weakest when accommodating changing product demands.

This is not the time to seek the future of the U.S. shipbuilding industry by looking into a rear-view mirror, despite our past achievements. The time has come to look port and starboard at our competition and pull ahead at flank speed, with government assistance (subsidy) as needed.

4. PRODUCTIVITY

The productivity of the U.S. shipbuilding industry has apparently declined over the past thirty years when compared to foreign competition in the ascendency.

A definition of the productivity term is most elusive, though it finds universal usage in everyday management decisions. Ideally, it should be indexed by a measure of physical output (properly adjusted for quality changes in a product) per unit of total resources cooperating in production. However, each subordinate term within the productivity definition offers insoluble complications. Physical outputs are heterogenous and show little or no correlation (e.g., manhours/ton of steel for an aircraft carrier, a submarine, a commercial tanker, or a quasi-milspec/non-milspec 'T' ship from NAVSEA Auxiliary Ship Program Office are quite different.)

Also, the increasing complexity of warships guarantees that manhours/ton of destroyer weight group in 1985 will be quite different from that of 1975. This illustrates that a comparison of productivity measures is difficult, even in the manufacture of the 'same' product.

Perhaps the most accurate overall index of productivity, in the industry, would be profitability in an economic sense (i.e., the asset/sales ratio perviously addressed). This approach requires caveat in that profits would have to be earned in a competitive environment, in which neither buyers nor sellers possess power over price and in which both are fully subject to economic incentives. These characteristics do not universally prevail in the overall U.S. naval and commercial shipbuilding business arena.

There are two 'indicators' which may guide productivity assessments: (a) value added/production worker . . . a variable dependent on the quality of capital and labor employed, together with the quantity of capital assets and (b) Management's view of productivity trends, though this may be from an American businessman's adversarial perspective.

At present, the U.S. shipbuilding value-added/worker does not rank highly when compared with other major national industries. This may be related to lessened devotion to the work ethic, labor usage, turnover, lagging capital investments, etc., because of uncertainties in the long-term future of the U.S. shipbuilding industry. In making comparisons with other industries, it should be recognized that the ship construction process will never benefit from the mass-production processes to the extent of the auto, appliance and other consumer goods industries. Therefore, the degree to which the U.S. shipbuilding industry lags will be one of relativity to its foreign shipbuilding competitors.

Many unique factors have contributed to the U.S. shipbuilidng decline and foreign successes, and analysts should not overlook the overall Gestalt of each industrial component in their assessments. Gestalt is a German term expressing shape, form or configuration, and when used in a system analysis context, it also reflects a point of view stressing appreciation of total system interactive and behavioral patterns. The productivity, form and behavior of the U.S. shipbuilding industry, must be analyzed from this point of view since the synergetic context will inevitably result in the whole being greater than the arithmetic sum of its individual parts.

The socio-economic and cultural variables; the government/business alliances; the corporate capital investments; the national goals for world dominance in various business enterprises; technology advancement and others, require individual comprehensive analysis followed by modeling which recognizes the effects of inter, and intra-element, reactions. It is not sufficient to analyze only the readily quantifiable elements such as capital investment, manhours/ship or process, labor rates, etc., in the assessment of individual U.S. yards, the national shipbuilding system, or as a unified force in competition with foreign producers.

A recent report "Technology Survey of Major U.S. Shipyards", prepared for the Maritime Administration (MARAD) in 1978, provided a technology survey of major U.S. shipyards using an analytic methodology developed by A&T Appledore (London) Ltd. This report noted that the Japanese had invested billions of dollars in the shipbuilding industry since World War II resulting in the production of merchant ships in less time, fewer manhours and less cost than that required in the United States (and other countries). The Japanese superb performance, benefiting from a technology factor and an initially lower labor rate, has received international attention and acclaim. However, to conduct analyses in this limited context of quantitive factors would over-simplify the input/output equation of productivity and present a myopic keyhole-view of each scenario. As stated: "The (MARAD) report deals with facilities, equipment and systems, but does not measure motivation, management or effort" . . . (or many other elements of the shipbuilding system Gestalt).

In addressing foreign competition, especially from Japan, one must proceed with caution and not permit limited and quantitative "analysis paralysis" to cloud the international variants inherent in business structures, cultural differences, etc. There are many areas of the shipbuilding process where Japanese cultural traits, manufacturing methods and technological innovations are not directly transferrable to the U.S. shipbuilding (or other) industries because of basic differences in social values, practices and business structures.

o The Japanese national commitment, with a strong government/banking/corporation/worker interlock, has resulted in industrial advancement with significant contributions to the Japanese economy over the past twenty years. An outgrowth of this commitment resulted in shipbuilding stability, during the tanker-boom (and non-boom) years, together with an efficient vertically-integrated supply system (usually within one corporate structure) . . . an element missing in the U.S. shipbuilding business.

o Many advantages accrue from this vertically-integrated supply structure:

- o During design -- Specific standardized items can be selected to outfit standardized ship designs. Cost is controllable within the corporation.
- o During manufacturing -- Quality and delivery can be controlled with minimized handling costs, inventory costs, reduced scrap margins, etc.

o The Japanese workforce within a corporation enjoys paternalistic management as does the corporation within the overall government structure.

o The Japanese shipbuilding industry has also developed an extensive and effective satellite subcontracting system (with reduced overhead) in the proximity of each main shipyard, sometimes staffed by skilled shipyard tradesmen who have retired at 55 years of age. The union structure of U.S. shipyards may be expected to militate against this practice where subcontract labor receives less pay and benefits than a full-time shipyard worker, and is supervised by shipyard management.

As stated earlier, given an expression of need and incentive, the U.S. shipbuilding industry can equal or exceed the achievements of foreign competitors. Apart from the World War II production of merchant ships in the United States, a subsequent yardstick of performance is difficult to identify. However, the multiple production of the DD963 Class at Ingalls (30 ships), the FFG 7 Class at Todd and Bath Iron Works (63 ships), the LST 1179 Class (17 ships) at National Steel and Shipbuilding Co. in the late sixties, and others, demonstrated the "can-do" spirit of our own shipbuilders . . . and their willingness to invest in plant improvements to maintain a leadership without peer in the warship construction industry. It is with this background that the U.S. Navy may look confidently to the future performance of our shipyards when called upon to respond to President Reagan's initiative to revitalize the fleet in the near term. Shipyard requirements, planning and construction times have been estimated, with contingency dependence on the final fleet mix for the 1990's. They show the following projections.

o The total 1981 force level, including Military Sealift Command and some Reserves, was 546 ships.

- o Five hundred ship force -- can be easily accomplished by existing shipyards in 14 years, but probably less than half can be afforded a viable workload. Attrition of numerous small and some large yards is possible.

- o Six hundred ship force -- within the capability of the industry, but again implying a shrinkage of the active shipbuilding base over a period of 14 years.

- o Seven hundred ship force -- would begin to t_x the capacity of the industry to accomplish in 14 years, as limited by labor and components supply factors under peace-time conditions. In this program, as in the next larger one, the limited number of nuclear-qualified builders could delay nuclear ship completions by some years.

- o Eight hundred ship force -- would press upon the physical capacity of all existing private and naval shipyards, including some now devoted to repair. Labor and components could be restricting. Without additional nuclear-qualified builders, or the substitution of conventional for planned nuclear-powered surface ships, the program would appear to require in excess of 16 years for completion. The simultaneous employment of various government policy options* might reduce this requirement to 11 years.

*Options are:
Extensive use of defense priority allocations for materials and components; government subsidy for or direct production of, weapons systems; policies to guarantee sufficient labor to critical yards with local shortages; substitution of conventional surface ships for those which would be nuclear; possible suspension of commercial construction.

The overall U.S. shipbuilding industry, given a reasonably assured long-term building program, can adapt to either lower or higher demand than currently experienced. A shrinkage in the number of firms could occur, and naval ship contract award policies, (multi-ship or other), could determine which firms will survive. If attrition among the large yards were to occur, as seems possible, the industry's ability to respond to surges in demand could be impaired.

In order to guarantee a timely response by the industry, government action under the Defense Production Act of 1950 may be required. This could suspend full dependence on market forces to obtain labor and materials. This may also include: (a) assigning priority to shipbuilding for raw materials and components and enforcing this; (b) suspending competitive bidding in ship construction and going to allocation procedures; and (c) underwriting special recruiting and training programs for shipbuilding skill groups; (d) resolving the bottlenecks created by conflicts between nuclear-powered ship planning and nuclear-qualified building capacity should also receive priority action.

The results of the aforementioned MARAD-sponsored report, "Technology Survey of Major U.S. Shipyards 1978," addressed 70 technology elements in each major U.S. shipyard and found technology shortfalls in 51 elements relative to foreign competition in merchant shipbuilding (figure 13). Many of these shortfalls are equally applicable to warship production in U.S. shipyards.

Technology comparisons, by major category, are shown in figure 14. It should be noted that the U.S. shipyards were only marginally superior in the Outfitting and Production Stores (Category b) and equal for Organization and Operating Systems (Category h). Other categories reflect shortfalls inclusive of services to humanity in the workplace (Category f), a sad commentary for an advanced Western civilization. The results of the report, while directly related to merchant ship production, may also be an indicator of certain warship production technology shortfalls in some categories . . . even though the United States has no peer in the free world.

There is no doubt that the industry will respond to the naval expansion program challenge with the U.S. Navy infusing "seed funds" to stimulate the

development and implementation of advanced manufacturing and shipbuilding technologies by suppliers and shipyard activities. The NAVSEA Manufacturing and Shipbuilding Technology Program objectives are focused on technology advancements which will reduce cost and schedules with quality improvements and enhancement of the industrial base state of preparedness.

No element of the U.S. shipbuilding industry is heavily capitalized in technology, relative to other industries, because of its nature as a labor-intensive industry. However, a trend is underway to improve this situation as witnessed by the implementation of computer-aided management, design, layout and production processes, automatic and semi-automatic welding equipment and larger lifting equipment to accommodate the increased use of modular construction. In the near future, laser welding and alignment, plasma cutting, air-cushion and water bearing materials handling, and to a limited degree, the use of robotics will be introduced in shipyards contributing to the expanded naval construction program.

5. THE SHIPBUILDING WORKFORCE

The MARAD-sponsored report 'Technology Survey of Major U.S. Shipyards 1978' gave the lowest rating (see figure 14) to Environment & Amenities (Category f), which covers the humane use of human beings:

F1 General Environmental Protection in the Workplace
F2 Lighting & Heating
F3 Noise Ventilation and Fume Extraction
F4 Canteen Facilities
F5 Washrooms, Toilets & Lockers
F6 Other Amenities

These are elements generally related to the services and personal support provided to shipyard employees. Employee attitude and some of these elements could impact productivity (e.g., protection from heat, cold, noise and other aspects of working conditions). Generally, U.S. shipyards do not measure up to major foreign shipyards in these environmental factors. Also, relatively little attention is paid to messing amenities. Better treatment of the labor force could be a key to reducing turnover and the maintenance of a proficient shipyard labor force, constantly retrained to handle the newest technologies and procedures. As evidenced overseas, shipyards can be modified to meet humane 20th century workplace standards.

The shipbuilding industry is compelled to maintain a labor-intensive posture because of the difficulty in applying mass-production techniques under present low-volume circumstances. Even each ship within a class takes on some aspects of a new product over a protracted construction program. These characteristics lead to shallow learning curves, or none at all. Production workers, or, broadly, those workers directly involved with the physical production of merchant ships and repair services, are a large percentage of the total labor force. In composition, this type of labor is dominated by 10 critical skills, which comprise about 65 percent of the production workers. They are:

1. Shipfitters
2. Riggers
3. Loftsmen
4. Welders and burners
5. Machinists
6. Electricians
7. Pipefitters
8. Sheetmetal workers
9. Boilermakers
10. Electronics mechanics

None of these categories are unique to shipbuilding since all of the skills are transferrable to other American industries in varying degrees.

Therefore, the shipbuilding industry, in periods of surge demand for new ship construction, should be able to draw on these skilled workers from other sectors of the economy. However, it should not be overlooked that U.S. shipyards, in some instances, have now become the "apprentice-schools" for other industries. Working conditions outside the U.S. shipbuilding industry are apparently more preferable.

Competition for workers is an unequal one in most respects. Shipyards pay less (figure 15) for the same skills than other construction does, and frequently require the workers to function in dirtier, more cramped, and noisier conditions. On the other hand, a long-term shipbuilding program can offer workers more stable employment and a fixed domicile location. Nonetheless, in periods of prosperity, shipyards tend to experience a rapid turnover, especially among younger workers who may regard shipbuilding as the vocation of last resort.

U.S. shipbuilding labor is craft-delineated, predominantly unionized, and in large part skilled or semi-skilled. However an infusion of new shipbuilding technology and improved working conditions could alter this characterization. Cost reduction motives are leading the yards to accelerate modular construction techniques, to introduce more numerical control machinery, to use downhand welding, to standardize major ships' parts, to move to product specialization (within yards) to the extent an unstable workload permits, and to the purchase of supplies instead of on-site production. Such promising procedures as increased use of computer graphics for design and lofting, laser alignment and welding, and robotization also will be adoptable by shipyards in the near future. Each of these tendencies should lessen the yards' needs for production workers, and could reduce the skilled craft bases of shipyard labor. The labor force could potentially be trained more quickly and cheaply, with the ability to expand rapidly in a mobilization or surge demand period.

Training periods for skilled labor in shipbuilding are normally of long duration and high cost before first-class journeyman status is reached. Figure 16 reflects selected shipyard production trades and associated training duration for qualification as first-class journeymen.

During periods of mobilization, however, the shipyards may revert to intensive, short-term, training programs to rapidly qualify workers; no doubt at some penalty in skill attainment and productivity; e.g., after 12 weeks of training, a welder can be assigned limited tasks in shipbuilding.

One particularly troublesome area of labor force shortage is that of naval architects and engineers (figure 17), a deficiency which is not as readily correctible by steps that make it possible to recruit more production workers. Naval architecture and marine engineering graduates are in great demand by governmental agencies and private ship design companies but nevertheless, there is difficulty in attracting and retaining young students to the shipbuilding industry because of its long-term uncertainty. Also, the recapturing of qualified personnel, who have migrated from the shipbuilding industry is an ever greater challenge.

The role of union influence in U.S. shipbuilding currently remains unaddressed. During World War II, union entrenchment occurred in the blue-collar and skilled areas and trade cross-training remains restricted today. (Welders cannot be used as burners or vice versa, though worker transfer between trades is allowed but with a loss in seniority.)

The importance of the worker as an integral member of a corporate entity is recognized under the paternalistic management structure of Japan. This is not generally evident in the U.S. shipbuilding industry, and the firms of

the Western world, though it has been tried and usually failed. The failed paternalistic practices of Henry Ford I, towards his executives, are well documented and interesting reading.

Attempts to cope with the human side of labor have often been superficial in our capitalistic system which venerates the profit ethic in the short-term. The profit ethic emerged in eighteenth century Great Britain but it reached its zenith of acceptance by both business and the public in America, during the period between the Civil War and World War I . . . The Age of Enterprise. At that time, the Darwinian theory of the struggle for existence and survival of the fittest, was most influential in social thought and supportive of the profit motive.

However, while corporate profit may be an objective measurement of corporate efficiency in allocating resources, it may not be a measure of its social responsibility to its workers, its customers, or the public at large.

Could it be that the corporate leaders in our shipbuilding industry have overlooked the social responsibility to their employees who labor under environmental conditions greatly substandard to their Japanese and European counterparts as shown in figure 14?

In general, the Japanese view the Western world's attempts to cope with the human side of the labor force as being superficial. The Western employers expect total commitments from each employee but limited commitment by the employing corporation. Short-term solutions to boost lagging production and to soothe emotional stress are skeptically greeted as management fads. Specifically targeted by workers are background music, suggestion boxes, psychological counseling, etc., which are repeatedly tried and abandoned.

Big Japanese corporations treat human resources as their most valuable asset. The hiring, the training, and the promotion of employees and managers are the responsibility of the corporation as a whole. Even a chief executive officer does not dangle the threat, implied or otherwise, of firing a subordinate. Instead, it is management's job to encourage working toward the shared goals of the firm by helping to satisfy the human needs of job satisfaction and self-fulfillment.

One Japanese plant manager who turned an unproductive U.S. factory into a profitable venture in less than three months is quoted as saying, "It is simple. You treat American workers as human beings with ordinary human needs and values. They react like human beings." Once the superficial, adversarial relationship between managers and trained workers is eliminated, they are more likely to pull together during difficult times and to defend their common interest in their firm's health.

In Japan, when a company has to absorb a sudden economic hardship such as a 25 percent decline in sales, the sacrificial "pecking-order" is firmly set. First the corporate dividends are cut. Then the salaries and the bonuses of top management are reduced. Next, management salaries are trimmed from the top to the middle of the hierarchy. Lastly, the rank and file are asked to accept pay cuts or a reduction in the work force through

attrition or voluntary discharge. In the United States, a typical American-owned firm would probably do the opposite under similar circumstances. Some American-based Japanese firms, such as Kawasaki, have been known to retain employees on full salary (during slack sales periods) and make them available for municipal service at no cost to local government!

It is basic Japanese theory that about 80 percent of a company's productivity and product quality problems must be solved by top management action. American management has either not yet realized this or is reluctant to make a major adjustment.

Implementation of the highly-touted Quality Control Circles as an American invention, gone foreign (to Japan) and now came home for use in various industries, is viewed with some amusement by the Japanese who know it is but a small element in their manufacturing effectiveness and product acceptance.

Japanese business has spent the past thirty years developing the concept of Quality Control Circles in an effort to rebuild their post-World War II economy. The idea is that five to ten rank and file factory or office workers whose jobs form natural work units meet on their own time, often with the participation of foremen and low-level supervisors, to analyze the work process and suggest ways to cut costs and improve productivity and product quality, safety, and on-the-job training. Management is expected to take their recommendations seriously. Japanese management maintains that it would be foolhardly not to encourage worker participation. After all, it is office and factory workers who are closest to many of the work snags and who can best suggest solutions. It is reported that the average Quality Circle in Japan produces 50-60 implemented suggestions per worker for a single year.

American managers have been impressed, especially after touring Japanese businesses. Over the past year, hundreds of businesses in the United States have experimented with Quality Control Circles. Yet very few of the over fifty large Japanese manufacturing firms in the United States have extensively used quality control circles. Most Japanese managers know that the establishment of them is not the first but the last step in building a corporation that will support a total commitment to product quality and increased productivity.

No concept has been more misunderstood by American managers, academics, and workers than productivity. For U.S. workers, a call for increased productivity carries with it the threat of layoffs. Managers consider productivity to be an economic trade-off between efficiency and product quality. Business school courses on management are often watered down to numerical games of inventory control and production flow in which financial budgeting and tight control are oversold as effective management tools. On production floors and in corporate offices, sociological verbiage has replaced a basic understanding of human behavior. The profit motive, sometimes to employee detriment, appears to reign supreme in industries of the Western world.

The Japanese recognize that technological innovation alone cannot generate high productivity, improved quality, and low worker turnover rates. Total reciprocal social commitment between the worker and the corporation is the

key factor which has the potential of rejuvenating our industries. This can be accomplished without becoming a ward of the corporation for a lifetime (as in the case of the Japanese) . . . a thought furthest from the mind of free-enterprising, mobile, American citizens.

Without a cultural revolution in management, the Quality Control Circle, or other isolated micro-elements of the Japanese business structure, will not produce, and should not be expected to produce, the desired effects for American private and public corporations. Nor can anyone in the United States guarantee that job security for the rank and file will ensure high productivity and product quality. With guaranteed job security, management's job becomes far more difficult and challenging if mutual commitment does not exist. However, without a management commitment to the personal welfare of its workers, it will be impossible to inspire spontaneous employee interest in company productivity and product quality.

American management has clearly not met the challenge in the case of shipyard work forces and most U.S. public and private enterprises where adversarial management/labor confrontations frequently occur.

For yet another time in its history, the United States faces the job of managing economic growth with an increasing scarcity of capital, raw materials, energy sources, managerial skill, and market opportunities. It is not going to be easy for the U.S. to learn Japan's secret. The secret is for top management to persuade middle management and workers that a lack of reciprocal commitment in the face of strong competition can destroy their industry. Such difficult persuasion is the potion for a complete cure. Productivity fads such as Quality Control Circles are, by comparison, "Band-Aids" when implemented with excessive expectations.

Throughout American history, relationships between U.S. companies and the labor unions have been adversarial in nature. This relationship is reflected in the attitude of the workers and the relationship between workers and their supervisors. In Japan, the company attitude towards the workers is paternalistic. Generally, only one union represents all production workers, whereas in many American shipyards there are five or more unions. In Japan, cross-trade training is emphasized to produce multi-craft workers for productivity enhancement. The multi-craft workers eliminate the redundant labor required by the labor contracts in the United States (a welder waiting while a burner burns or a machinist removes a bolt) and the associated loss of production while the correct mechanic is obtained for the unexpected small job which is interrelated to the main work. Even without the multi-craft workers, the one-union concept permits greater utilization of the lead craft concept where the foreman for one of the major trades in a compartment directs and coordinates the effort of all other trades in the compartment without risk of jurisdictional disputes. The result is on-the-spot coordination and problem resolution with resultant increases in production.

New hires in Japanese shipyards are usually hired straight out of high school. The first three months after hire are spent on indoctrination, basic training and familiarization. The next nine months are devoted to on-the-job training. After two additional years the employee is rated as a journeyman. The result of this rapid, intensive training is a high skill level in the labor force.

Because of labor customs, the Japanese journeyman usually has job security with no concern about lay-offs. Once a worker passes an indoctrination period, he is guaranteed a job until he retires at age 55. Workers in Japan are traditionally given increases based on seniority, which is an incentive for the workers to remain at one place of employment. In Japan, the shipyard worker is at the upper level of blue collar pay, and a shipyard job is a very desirable one. In the U.S., shipyard wages are at the low end of the blue collar payscale. The results of these conditions in the labor market of Japan are that shipyard workers are company-oriented, committed to long term employment, and highly regarded by their peers. High worker productivity can therefore be understood.

As part of a sociological system of low mobility, the average Japanese worker is highly dedicated to his job, the company for which he works, and to his skills as a craftsman. This is a part of his upbringing and an integral part of the society in which he lives. The peer pressure to perform and to do a good job is very high. It is not unusual for a worker who gets fired for poor performance (a very rare occurrence) to be ostracized, by his community, as an undesirable to the extent that he and his family may leave the area in which they are living.

The same peer pressure is a significant ingredient in shipyard safety programs where the employees are divided into groups of 10-15 workers. The groups compete against each other for small prizes on a monthly basis. Any member of a group who commits an unsafe act, thereby preventing the group from winning the prizes and the recognition attached thereto, comes under intense group pressure not to repeat the mistake.

These insights into the American and Japanese labor forces allow "a snapshot" of cultural and shipyard management elements which contribute to a fuller appreciation of work forces which can either make or break an enterprise. Without consideration of these vital elements, centered around the humane use of human beings, any assessment of shipbuilding technology, functional management, and production processes, will find only partial definition of the system under review . . . with incomplete findings and conclusions.

6. PARTNERSHIP

A partnership prevails when associations occur which involve multiple investments with the sharing of risks and profits in a joint venture of mutual interest to various partners.

In the course of this paper, reference has been made to the "military-industrial complex" which has periodically provided much needed stimulus to the overall American economy during most wars and conflicts from the Civil War (1861-1865) to the present. It is possible to track U.S. industrial "boom" cycles as synchronous with periods of national and international conflicts, and their weapon demands which have repeatedly taxed the ingenuity of U.S. industry. As an "Arsenal of Democracy", and during an era of renaissance, U.S. industry has set an example of creativity, productivity and technological advancement for the world to follow . . . and can do so again, in all industries including shipbuilding.

Economists have repeatedly endeavored to analyze the dynamic U.S. economic system. Lord Maynard Keynes (1883-1946) advocated a focus on short-term comprehensive planning (without an assumption that all inputs to an economic model should be treated as variables) because: "in the long-run we all are dead." Keynesian Economics during the 1930's did contribute to a partial recovery of the American economy. However, the major recovery of the U.S. economy was a by-product of the World War II industrial base expansion, working in partnership with the military element of the U.S. government to achieve a common goal . . . the defeat of well-defined enemy forces. The infra-structure of this industrial resurgence also contained many examples of cooperative partnership which displayed the versatility and supremacy of the U.S. work force. Overall, the "military-industrial complex" contributed magnificently to national survival in time of war. Regrettably, the industrial momentum was usually lost in time of peace, as the U.S. economy attempted to return to the classical free-enterprise system, as advocated by Adam Smith in his book "The Wealth of Nations" during 1776.

Since the global economic system does not always adhere to purist "free-enterprise system" principles, a modified version of Adam Smith's precepts must occur for U.S. industry to reestablish a position of eminence in the peace-time marketplace.

Today, the United States and Great Britain are experimenting with the doctrines espoused by Milton Friedman (University of Chicago) who is from the "monetary school" of economists. The "monetarists" emphasize the money supply as a regulator of economic activity. Three basic assumptions are used: the velocity of money circulation is fairly stable; money influences the price level; and money supply affects the levels of output and employment. By-products of this doctrine are manifested today in high unemployment, an unsatisfactory balance of payments and high interest rates which regulate demand of the money supply. This limits industrial investment for the production of goods and services. Classical economic theories, extant throughout the "Dismal Science", have yet to provide expost-facto explanation of the correlation between high and low employment statistics with high inflation factors. They also have not presented a comprehensive Gestalt appreciation of national and international economic system dynamics and their impact on industrial bases.

By selecting shipbuilding as the subset economic element of interest, and analyzing past U.S. achievements and those countries enjoying present leadership in the field, a common gene can be isolated. The gene is PARTNERSHIP. This partnership must extend from the U.S. government (with minimal but effective regulation), through the industrial enterprise to the workers and the public it serves. While other countries advocate socialism to achieve this goal (by vesting the ownership and control of the means of production in the community as a whole) the inventiveness of perceptive American enterprise should seek a middle ground between socialism and the present U.S. industrial morality . . . which has obvious shortcomings. Lessons can be learned from our competitors, though a "cloning" course of action is not advocated.

The lowest level, and simplistic level of co-worker partnership should continue to be fostered via the "Quality Circle" involvement in production processes but expectations should not be overly optimistic.

The worker, union and management partnership should be fostered to achieve improved productivity by the increased use of technology; but without detriment, and possibly with gain, to all parties involved. (e.g., Japan has outdistanced other countries in the use of robots throughout industry but the Japanese do not perceive the robot as an employment threat.) Japan has 75,000, USA 3700, Sweden 1200, Germany 1133, Italy 400 and Great Britain 371 robots. Cooperation must replace confrontation at all levels in government and business enterprises.

Intra-national partnership in technology development and the cross-fertilization of ideas should prevail even though, at first glance, this may compromise proprietary rights and appear to run counter to the maintenance of competitive business initiatives.

Intra-national partnership in the development of technologies for marketing, management, research and development, manufacturing, and life-cycle support should be developed.

The ultimate cooperative partnership should be enabled between the industry, the government and the public it serves since the multiplier effect of U.S. shipbuilding on the total industrial base is significant. The estimate shows that $1 of shipyard sales can generate business for other industries in the $4 to $5 range. This input to the GNP is most significant and can be improved upon by partnership in expanding the U.S. fleet assets, rebuilding the U.S. merchant marine and modernizing our shipbuilding industrial base.

7. CONCLUSION

This paper has addressed many areas germane to a partial understanding of the U.S. shipbuilding industry Gestalt, in a dynamic national and international environment of competitive stress and with fluctuating forces of supply and demand.

As stated earlier, there are historical bases for shipbuilders to take pride in their business acumen, their technological prowess and skill of their craftsmen. The Arsenal of Venice operation used many sound management precedents; the allocation of resources to public and private shipbuilding sectors . . . leading one to believe that "nothing is as potent as a new idea who's time has come." World War I and II showed the spirit of international cooperation between America and Great Britain in the advancement of shipbuilding, through technology transfer which facilitated a unique technological partnership.

The challenge of constructing an expanded high-quality U.S. naval fleet is now to the forefront of thinking for politicians, military planners, the shipbuilders, and the taxpayers who will underwrite the enterprise. Over the past thirty years we have heard "The Russians are Coming" from the U.S. militarist media. We now hear that "The Japanese are Coming" from U.S. business sectors. However, the true competitor becomes more evident with each passing day . . . it is ourselves.

In every epoch of American history, industrial performance has admirably responded to the greatest challange, giving spin-off benefit to the overall American standard of living and psychological uplift to its work force. The period of the 1980's could be yet another beginning in industrial resurgence with partnership throughout all levels, but without succumbing to a Socialistic trend in the achievment of our objectives.

Major shipyards spontaneously invested over $1 billion in major capital improvements pointed to greater building capacity during the 1970's. To this must be added technology investment for future productivity improvements. Some examples of shipbuilding improvements are:

> Avondale Shipyards, Inc. has invested over $6 million in a new automated pipe shop. In addition, $40 million is being invested in a new dry dock and facilities.
>
> Bath Iron Works Corp. is making a large extension to its assembly and pre-outfitting operations. It is also investigating facilities at Portland, Maine to handle larger ship repairs.
>
> Todd Shipyards Corp. (Los Angeles) is installing a synchro-lift which will increase lift capacity from 13,000 to 15,000 tons from a land-level facility.
>
> Todd (Seattle) is moving a large dry dock from San Francisco and putting $16 million into new outfitting piers at Seattle to handle battleship-size ships.

Newport News Shipbuilding has installed a $29 million nuclear refueling facility; is making a $20 million upgrade of its commercial "North Yard" to take on Navy work, and plans to spend $400 million for further improvements over the next 5 years. In addition, Newport News is making a major expansion in its apprentice hiring and training program.

Lockheed Shipbuilding and Construction Co. (Seattle) is contemplating extending piers and dredging at piers to handle deeper draft large combatant ship overhauls.

National Steel and Shipbuilding Co. (San Diego) has invested $6 million in on-going capital improvements. The company is also considering investing an additional $40 million and opening a South Bay Annex.

Industrial engineers are beginning to recognize that "Man is the only complex and versatile servo-mechanical system that can be mass-produced by unskilled labor." His training is key and should be afforded more support in advance of ship construction authorizations.

An active shipbuilding industry can attract trainees (Bath Iron Works reportedly has 1200 applicants for 44 apprentice-program positions) if a more humane working environment is provided, at least on a par with their counterparts in overseas shipyards. To this end the U.S. government in partnership with public and private shipyards should consider the immediate underwriting of shipbuilders trade training to meet the future building demands. These demands are predicted to occur from 1983 onward, for at least 14 years, to meet naval fleet expansion objectives. This buildup could be further increased but with contingency upon the Reagan Administration's realization that (a) the mercantile marine is the fourth active military service during mobilization, and (b) a reallocation of funds will be necessary to rebuild the U.S. mercantile marine. Government assurances made during the 1970 decade, regarding the rebuilding of the mercantile marine, did not mature, causing shipbuilder financial loss and an even greater loss in government/industry partnership confidence.

In summary, the U.S. shipbuilding industrial base inside and outside of the naval shipbuilding sector should be recognized as having both active and latent vitality. This vitality cannot be tapped until government decision-making, affecting the framework of an expanded naval shipbuilding program, and the immediate need for a revitalized U.S. flag merchant marine is completed. Time is of the essence as workload projections show alarming trends, the layoff of shipyard workers continues (figure 18), as the supplier base continues to contract.

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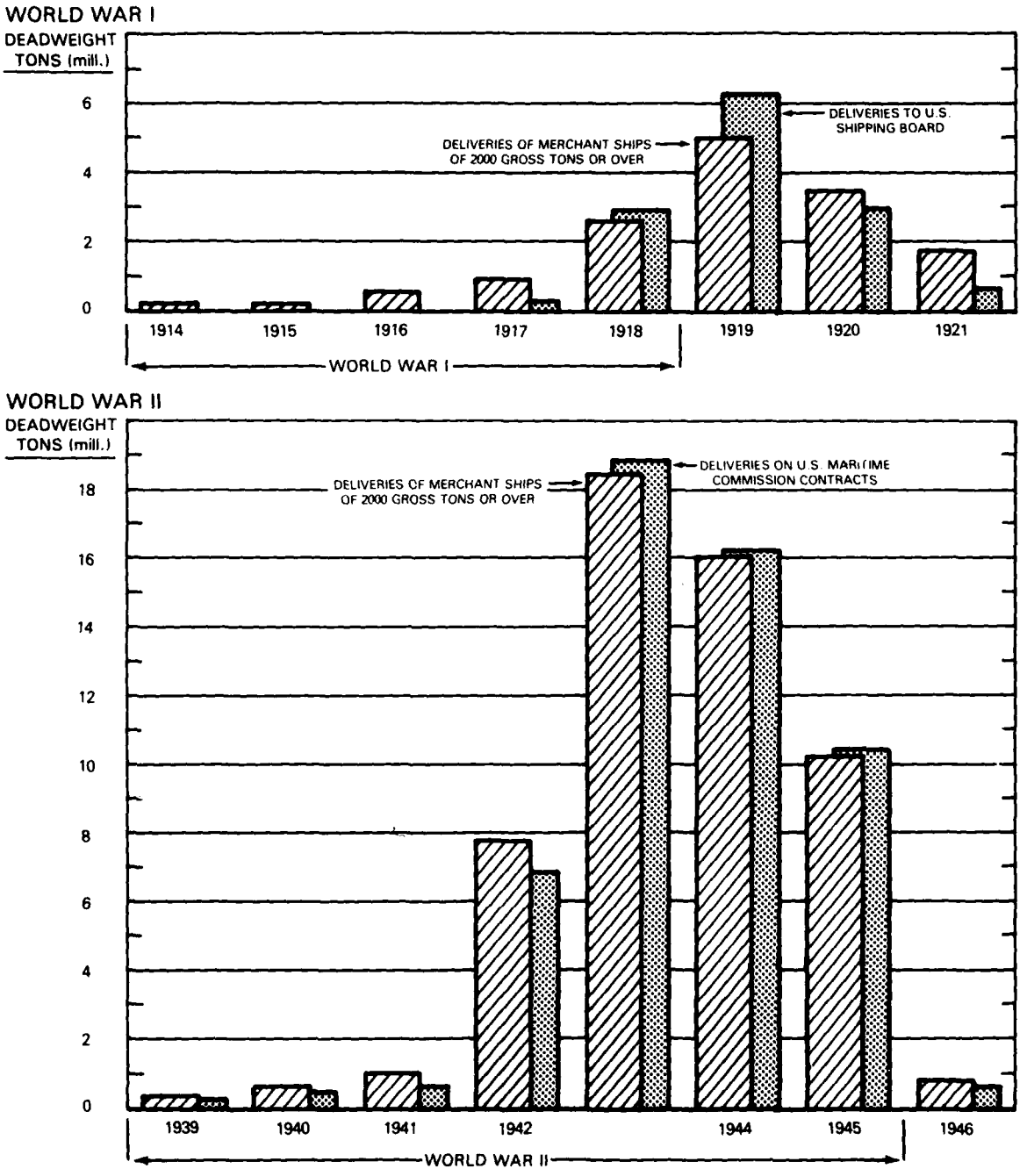


FIGURE 1
SHIPBUILDING IN THE U.S. DURING TWO WORLD WARS
EXCLUDING CONSTRUCTION BY THE NAVY

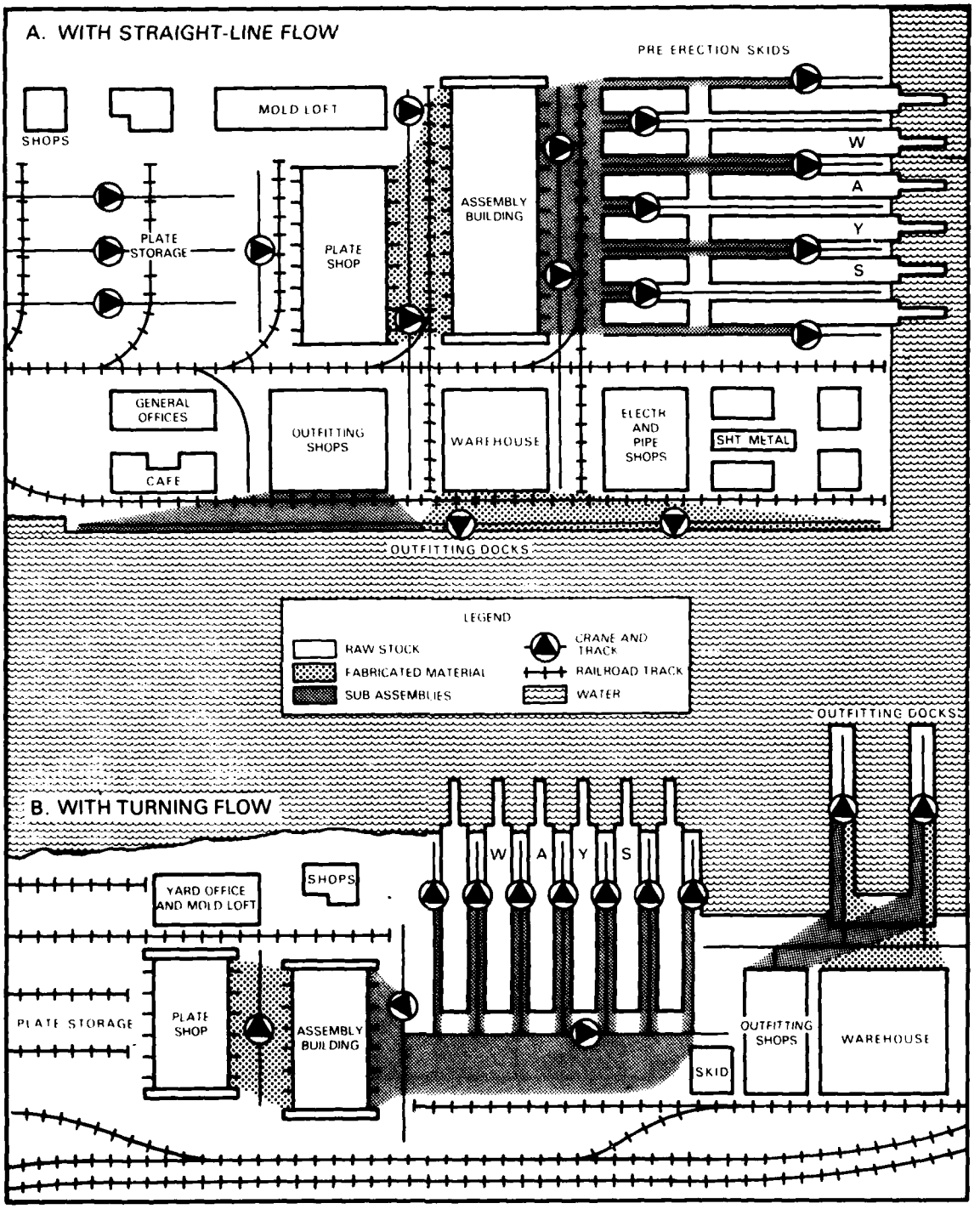


FIGURE 2
LAYOUTS OF SHIPYARDS FOR MULTIPLE PRODUCTION

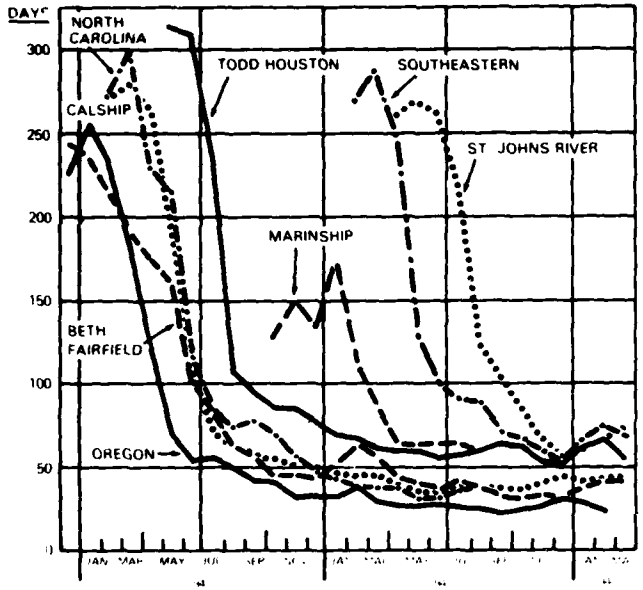


FIGURE 3A
CONSTRUCTION TIME OF LIBERTY SHIPS IN SELECTED YARDS
AVERAGE NUMBER OF DAYS FROM KEEL LAYING TO DELIVERY FOR VESSELS DELIVERED EACH MONTH DECEMBER 1941 MARCH 1944

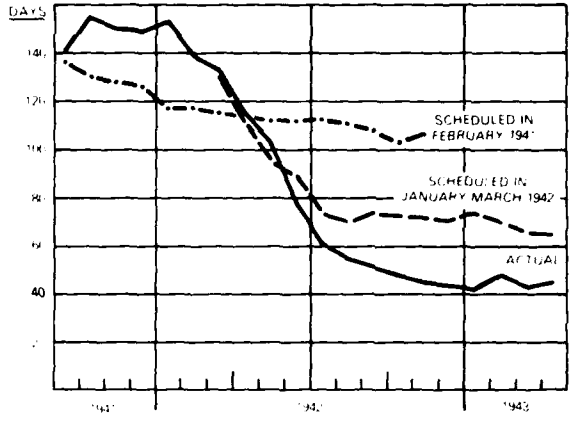


FIGURE 3B
ACTUAL LIBERTY SHIP PRODUCTION RATE vs PLANNED SCHEDULE
TIME ON THE WAYS OF LIBERTY SHIPS LAUNCHED EACH MONTH COMPARED WITH SCHEDULED TIME, SEPTEMBER 1941-APRIL 1943

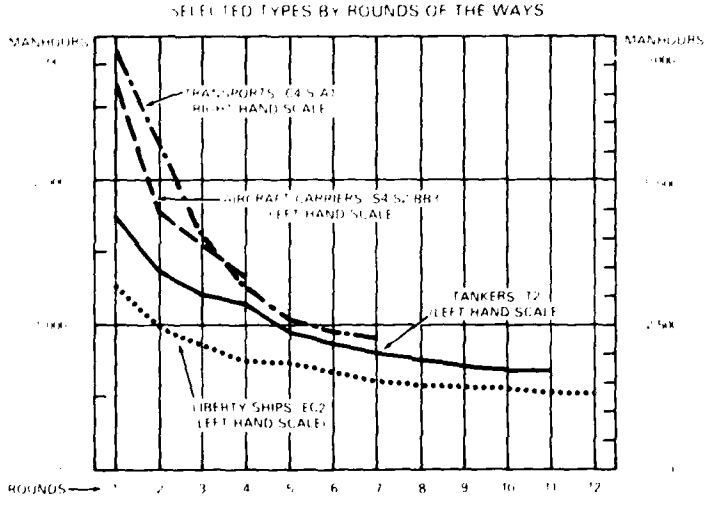


FIGURE 4
MANHOURS PER SHIP FOR VESSELS BUILT IN NEW YARDS

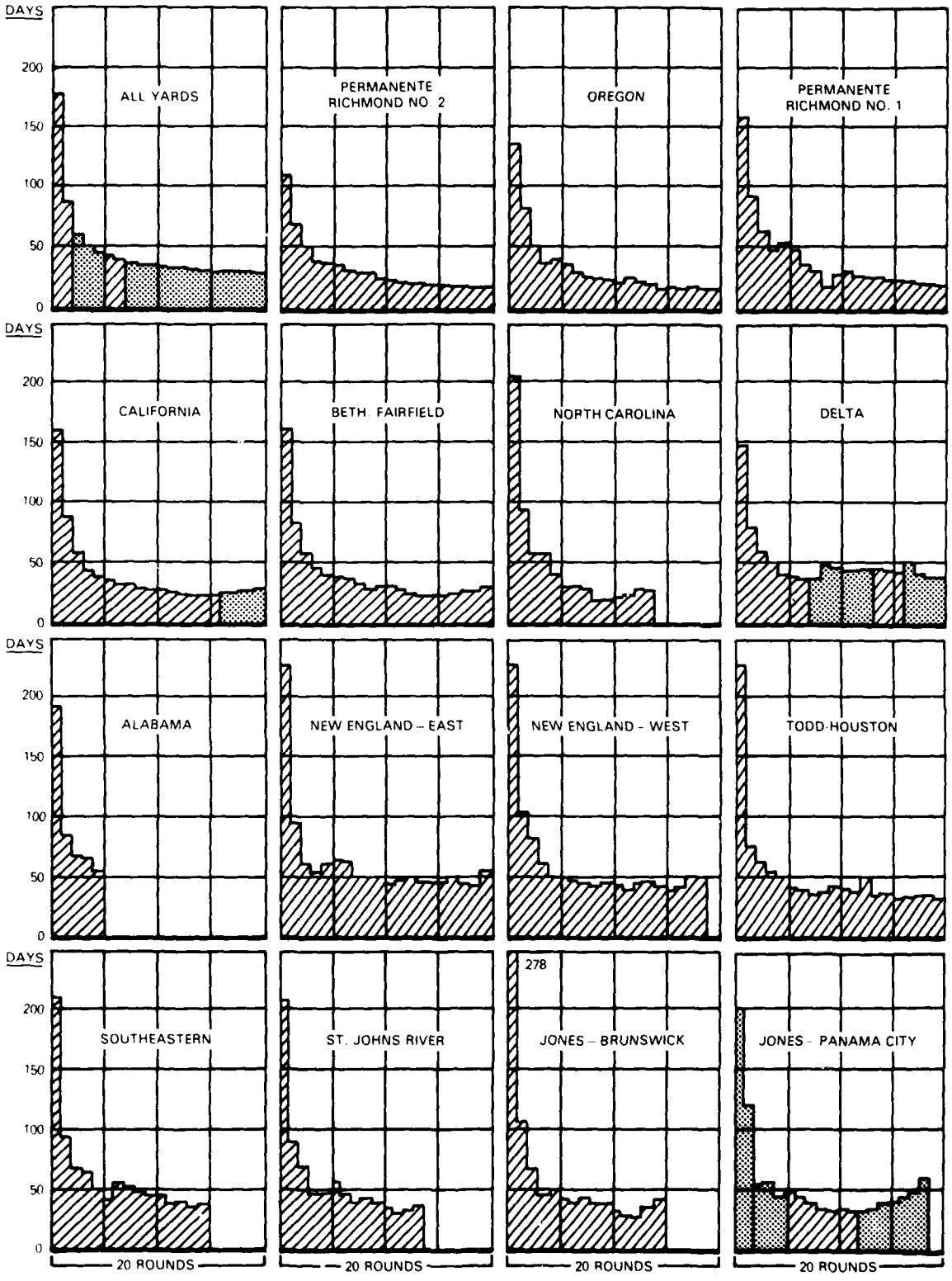


FIGURE 5
TIME ON THE WAYS OF LIBERTY SHIPS, IN SELECTED YARDS
AVERAGE NUMBER OF DAYS FROM KEEL LAYING TO LAUNCHING FOR EACH SUCCESSIVE ROUND OF THE WAYS

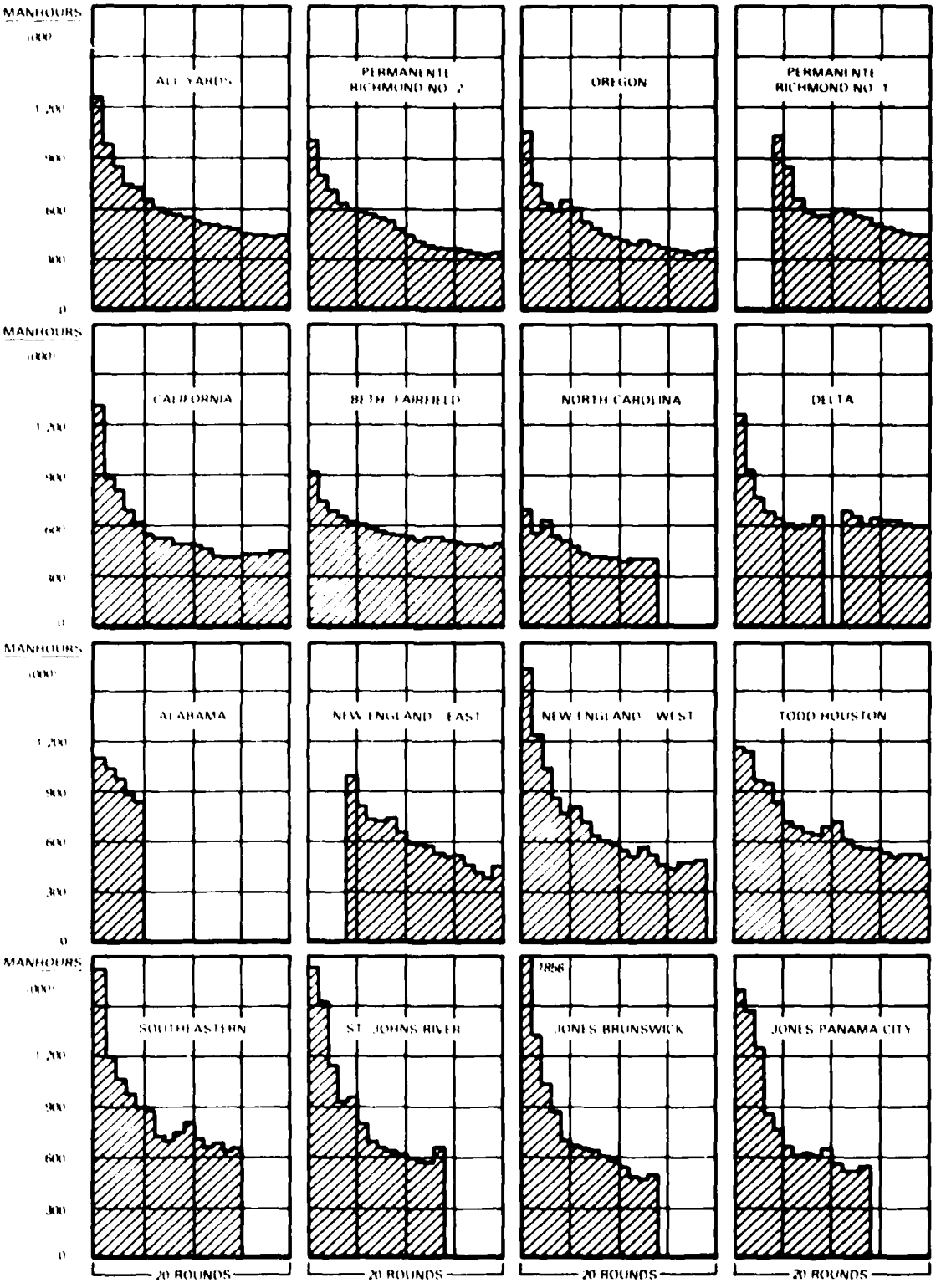


FIGURE 6

MANHOURS PER SHIP FOR LIBERTY SHIPS, BY ROUNDS

AVERAGE FOR EACH SUCCESSIVE ROUND OF THE WAYS IN SELECTED YARDS

FIRM SIZE BY EMPLOYEES	PERCENT OF FIRMS	PERCENT OF EMPLOYEES	PERCENT OF PAYROLL	PERCENT OF PRODUCTION WORKERS	PERCENT VALUE ADDED	PERCENT VALUE OF SHIPMENTS
1-4	23.1	.1	.1	.1	.1	.1
5-9	11.9	.3	3	.3	.4	.3
10-19	13.1	.6	.6	.6	.7	.7
20-49	14.7	1.6	1.5	1.8	1.6	1.6
50-99	10.6	2.4	2.3	2.6	2.2	2.5
100-249	11.2	6.1	6.0	6.4	6.7	6.8
250-499	7.6	9.0	8.8	9.2	10.4	10.3
500-999	3.5	8.6	8.8	9.1	10.3	9.8
1,000-2,499	2.6	13.4	14.1	14.0	12.8	14.3
2,500 AND OVER	1.7	57.8	57.5	55.8	54.8	53.6
	100.0	100.0	100.0	100.0	100.0	100.0

SOURCE U.S. BUREAU OF THE CENSUS 1977

FIGURE 7
MAJOR U.S. SHIPYARD STATISTICS

SHIPYARDS	CURRENT EMPLOYMENT	POTENTIAL MOBILIZATION EMPLOYMENT	LOCATION
CATEGORY I. COMBATANT CAPABLE (PLUS AMPHIBIOUS/AUXILIARY AND MERCHANT)			
1 BATH IRON WORKS	5,300	12,000	BATH, ME
2 GENERAL DYNAMICS, QUINCY	4,900	24,000[4]	QUINCY, MA
3 GENERAL DYNAMICS, GROTON	22,300	30,000	GROTON, CT
4 NEWPORT NEWS SHIPBUILDING AND DRYDOCK	22,400	38,000	NEWPORT NEWS, VA
5 LITTON, INGALLS	17,000	21,000[4]	PASCAGOULA, MS
6 AVONDALE	7,300	18,000	NEW ORLEANS, LA
7 TODD, SAN PEDRO	2,900	8,000	SAN PEDRO, CA
8 LOCKHEED	2,300	6,600	SEATTLE, WA
9 TODD, SEATTLE	3,300	7,200	SEATTLE, WA
CATEGORY I TOTALS	87,700	164,800	
CATEGORY II. AMPHIBIOUS/AUXILIARY-CAPABLE (PLUS MERCHANT)			
1 SUN SHIPBUILDING AND DRYDOCK	4,000	35,000[5]	CHESTER, PA
2 MARYLAND SHIPBUILDING AND DRYDOCK	1,300	12,000	BALTIMORE, MD
3 BETHLEHEM STEEL, SPARROWS POINT	2,300	15,500[4]	SPARROWS POINT, MD
4 NATIONAL STEEL AND SHIPBUILDING	6,400	16,800	SAN DIEGO, CA
5 MARINETTE MARINE[2]	800	1,200	MARINETTE, WI
CATEGORY II TOTALS	14,800	80,500	
CATEGORY III. MERCHANT-CAPABLE (ONLY)			
1 NORFOLK SHIPBUILDING AND DRYDOCK	2,000	3,400	NORFOLK, VA
2 ALABAMA DRY:)CK AND SHIPBUILDING	800	5,400	MOBILE, AL
3 TAMPA SHIP REPAIR AND DRYDOCK	1,200	1,400	TAMPA, FL
4 TODD, HOUSTON	300	2,300	HOUSTON, TX
5 TODD, GALVESTON	800	5,000	GALVESTON, TX
6 LEVINGSTON	1,500	4,000	ORANGE, TX
7 EQUITABLE	800	13,000	NEW ORLEANS, LA
8 BETHLEHEM STEEL, SAN FRANCISCO	1,000	3,500	SAN FRANCISCO, CA
9 AMERICAN SHIP, LORAIN	500	3,600	LORAIN, OH
10 BAY SHIPBUILDING	1,700	1,800	STURGEON BAY, WI
11 PETERSON BUILDERS[3]	700	1,200[4]	STURGEON BAY, WI
CATEGORY III TOTALS	11,300	44,600	
TOTAL	113,800	289,900	

1 COMBATANT CAPABLE ONLY, NO[illegible] EAR SUBMARINES
2 SMALL COMBATANT AUXILIARY CAPABLE ONLY
3 RECENT NAVSEA REASSESSMENT INDICATES THAT PETERSON AND TACOMA BOAT (NOT LISTED) CAN BUILD SMALL COMBATANTS [illegible] PGM ALSO
4 THESE DATA MAY BE TOO LOW
5 THIS FIGURE MAY BE TOO HIGH

SOURCE: NAVSEA MEMORANDUM

FIGURE 8
MAJOR U.S. SHIPYARD WORKFORCE

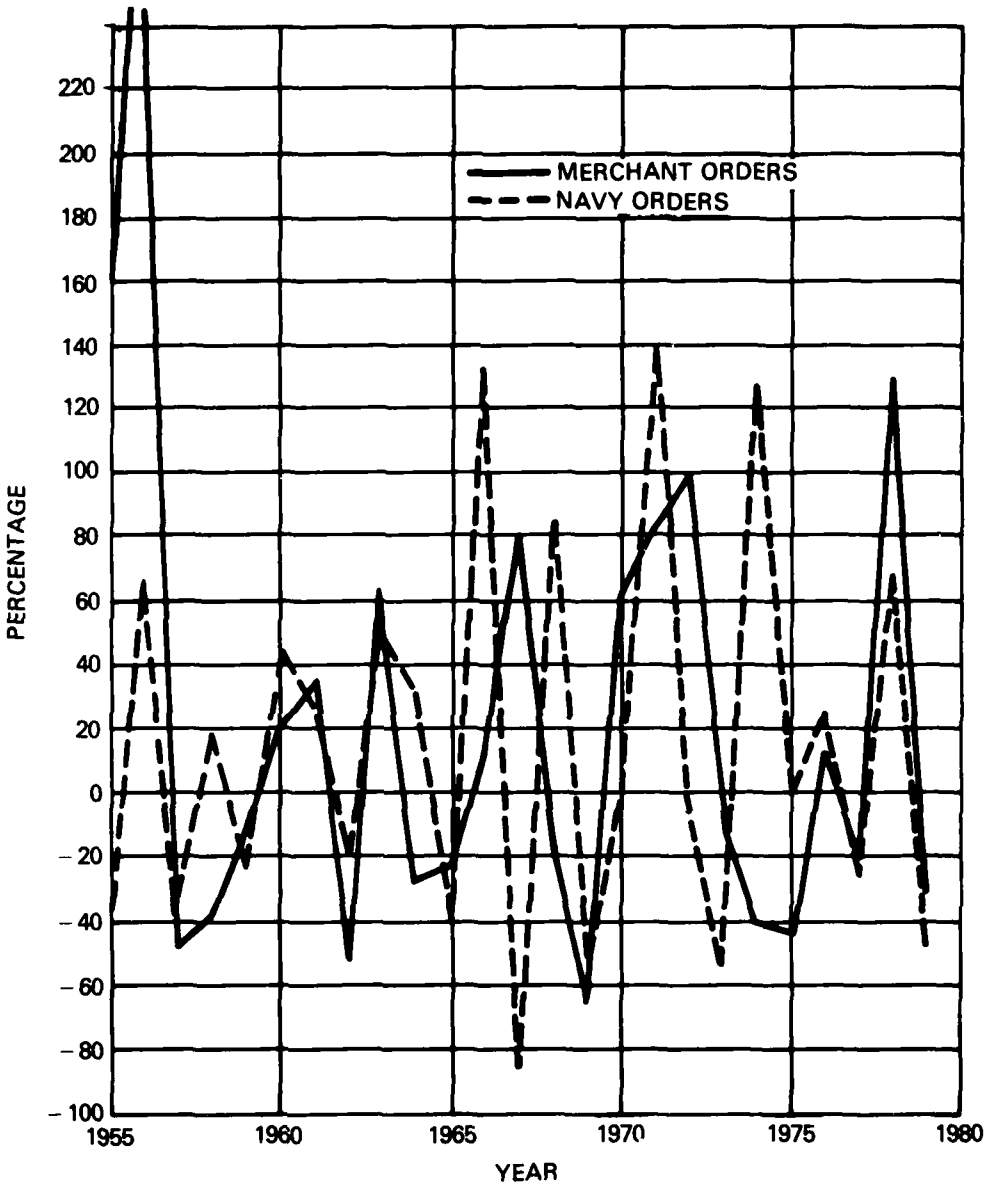


FIGURE 9
ANNUAL PERCENTAGE CHANGES IN ORDERS, 1954-1979

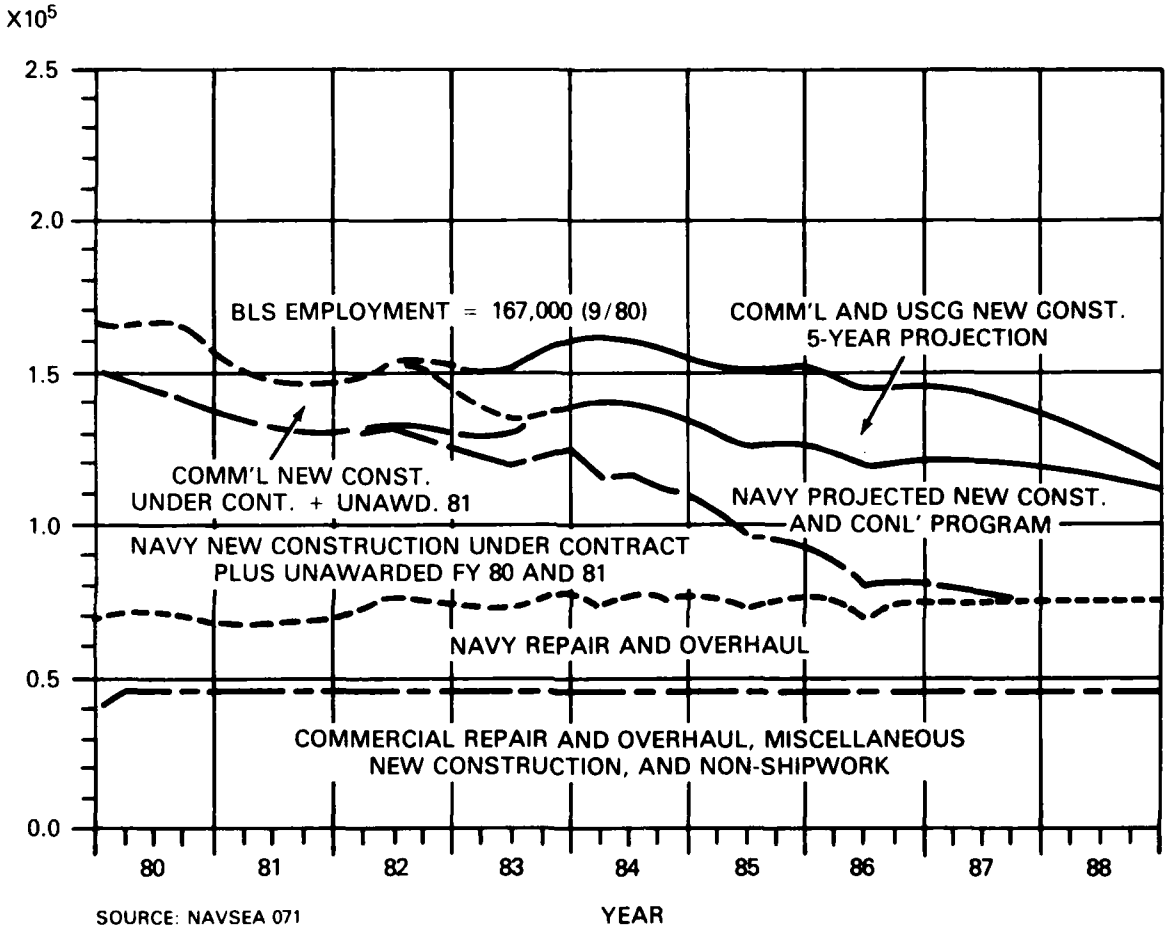


FIGURE 10
PRIVATE SHIPYARD EMPLOYMENT FORECAST
MARCH 16, 1981

INPUT	VALUE / $100 OF PRODUCT
1. CARBON STEEL	$7.75
2. ALLOY STEEL	.38
3. STAINLESS STEEL	.17
4. COPPER	.40
5. ALUMINUM	.40
6. METAL CASTINGS	.21
7. LUMBER	.33
8. GLASS FIBER	.09
9. FINISHES AND RESINS	.50
10. FABRICATED PLASTIC AND RUBBER	.10
11. FASTENERS	.25
12. BEARINGS AND GEARS	.07
13. ENGINES AND MOTORS	1.17
14. ALL OTHER MATERIALS	22.15
15. VALUE ADDED	66.03
VALUE OF WORK DONE	$100.00

FIGURE 11(a)
AVERAGE U.S. SHIPYARD VALUE-ADDED PER $100 OF COMMERCIAL SHIP CONSTRUCTION

INDEX	INDUSTRY (SIC CODE)						
	3731	3312	3441	3494	3531	3541	3721
1. PAYROLL / EMPLOYEE	$14,136	$19,745	$13,228	$13,495	$16,398	$15,981	$17,853
2. PRODUCTION WORKERS AS PERCENT OF TOTAL EMPLOYEES	79	79	73	69	71	73	53
3. AVERAGE HOURLY EARNINGS OF PRODUCTION WORKERS	$6.52	$9.94	$5.80	$6.08	$8.02	$7.08	$7.59
4. VALUE ADDED / EMPLOYEE	$21,681	$34,694	$25,777	$31,141	$36,986	$31,423	$36,525
5. PAYROLL AS PERCENT OF VALUE ADDED	65	56	51	43	44	50	49
6. VALUE ADDED / PRODUCTION WORKER HOUR	$13.80	$22.92	$17.75	$22.63	$27.00	$24.45	$34.96

SOURCE: U.S. BUREAU OF THE CENSUS

STANDARD INDUSTRIAL CODES (SIC):

3731 – SHIPBUILDING AND REPAIRING
3312 – BLAST FURNACES, STEEL WORKS
3441 – FABRICATED STRUCTURAL METAL
3494 – VALVES AND PIPE FITTINGS
3531 – CONSTRUCTION MACHINERY
3541 – MACHINE TOOLS
3721 – AIRCRAFT

FIGURE 11(b)
VARIOUS INDICES OF LABOR COST IN SHIPBUILDINGS AND COMPARABLE INDUSTRIES, 1977

COMPONENT CATEGORY	NO. OF U.S. FIRMS (a)	EUROPEAN AND JAPANESE FIRMS LISTED (b)
AIR CONDITIONING PLANT	3	26
ANCHORS	1	15
BEARINGS, STERN TUBE (LARGE)	5	15
BEARINGS, THRUST (LARGE)	3	14
BOILERS, AUXILIARY	8	18
BOILERS, MAIN	8	14
CABLE, ELECTRIC	38	28
CHAIN, ANCHOR	1	20
COMPRESSORS, AIR	13	34
CONDENSERS	9	11
CONSOLES AND CONTROL EQUIPMENT, BRIDGE	13	24
CONSOLES AND CONTROL EQUIPMENT, CENTRAL	13	26
CRANES, DECK	18	24
GEARS, REDUCTION	9	24
GENERATOR, ELECTRIC, DIESEL	23	51
GENERATOR, ELECTRIC, GAS TURBINE	23	7
GENERATOR, ELECTRIC, STEAM TURBINE	23	6
HYDRAULIC POWER EQUIPMENT	10	22
MOTORS, ELECTRIC	20	29
PROPELLERS, FIXED PITCH	6	20
PROPELLERS, CONTROLLABLE PITCH	4	25
PUMPS, FUEL OIL	5	23
BILGE	5	23
LUBE OIL	5	20
SEWAGE TREATMENT, EQUIPMENT (PACKAGE UNIT)	6	17
STEERING GEAR	10	17
SWITCHBOARDS	14	52
VALVES	45	118
WINCHES	20	33
WINDLASS	14	26
ENGINES, DIESEL		
ABOVE 750 THRU 1600 BHP	10	66(c)
ABOVE 1600 THRU 3600 BHP	7	32
TURBINES, MAIN PROPULSION		
GAS	4	12
STEAM-NON-NUCLEAR	3	11

(a) NAVSEA SHIPBUILDING SUPPORT OFFICE (NAVSHIPSO)
(b) INTERNATIONAL SHIPBUILDING & SHIP REPAIR DIRECTORY
(c) INCLUDES 11 SHIPBUILDING FIRMS

FIGURE 12
U.S. SHIPBUILDING SUPPORT BASE

A: STEELWORK PRODUCTION
- A1 PLATE STOCKYARD AND TREATMENT
- A2 STIFFENER STOCKYARD AND TREATMENT
- A3 PLATE CUTTING
- A4 STIFFENER CUTTING
- A5 PLATE AND STIFFENER FORMING
- A6 SUB ASSEMBLY
- A7 FLAT UNIT ASSEMBLY
- A8 CURVED AND CORRUGATED UNIT ASSEMBLY
- A9 3-D UNIT ASSEMBLY
- A10 SUPERSTRUCTURE UNIT ASSEMBLY
- A11 OUTFIT STEELWORK

B: OUTFIT PRODUCTION AND STORES
- B1 PIPEWORK
- B2 ENGINEERING/MACHINE SHOP
- B3 BLACKSMITHS
- B4 SHEETMETAL WORK
- B6 ELECTRICAL
- B7 RIGGING
- B8 MAINTENANCE
- B9 GARAGE
- B10 GENERAL STORAGE
- B11 AUXILIARY STORAGE

E: LAYOUT AND MATERIAL HANDLING
- E1 LAYOUT AND MATERIAL FLOW
- E2 MATERIALS HANDLING

F: AMENITIES
- F1 GENERAL ENVIRONMENTAL PROTECTION
- F2 LIGHTING AND HEATING
- F3 NOISE, VENTILATION AND FUME EXTRACTION
- F4 CANTEEN FACILITIES
- F5 WASHROOMS/WCs LOCKERS
- F6 OTHER AMENITIES

G: DESIGN, DRAFTING, PROD. ENGR'G & LOFTING
- G1 SHIP DESIGN
- G2 STEELWORK DRAWING PRESENTATION
- G3 OUTFIT DRAWING PRESENTATION
- G4 STEELWORK CODING SYSTEM
- G5 PARTS LISTING PROCEDURES
- G6 PRODUCTION ENGINEERING
- G7 DESIGN FOR PRODUCTION
- G8 DIMENSIONAL & QUALITY CONTROL
- G9 LOFTING METHODS

C: OTHER PRE-ERECTION ACTIVITIES
- C1 MODULE BUILDING
- C2 OUTFIT PARTS MARSHALLING
- C3 PRE-ERECTION OUTFITTING
- C4 BLOCK ASSEMBLY
- C5 UNIT AND BLOCK STORAGE

D: SHIP CONSTRUCTION AND INSTALLATION
- D1 SHIP CONSTRUCTION
- D2 ERECTION AND FAIRING
- D3 WELDING
- D4 ON-BOARD SERVICES
- D5 STAGING AND ACCESS
- D6 PIPEWORK
- D7 ENGINE ROOM MACHINERY
- D8 HULL ENGINEERING
- D9 SHEETMETAL WORK
- D11 ELECTRICAL
- D12 PAINTING
- D13 TESTING AND COMMISSIONING
- D14 AFTER LAUNCH

H: ORGANIZATION AND OPERATING SYSTEMS
- H1 ORGANIZATION OF WORK
- H2 CONTRACT SCHEDULING
- H3 STEELWORK PRODUCTION SCHEDULING
- H4 OUTFIT PRODUCTION SCHEDULING
- H5 OUTFIT INSTALLATION SCHEDULING
- H6 SHIP CONSTRUCTION SCHEDULING
- H7 STEELWORK PRODUCTION CONTROL
- H8 OUTFIT PRODUCTION CONTROL
- H9 OUTFIT INSTALLATION CONTROL
- H10 SHIP CONSTRUCTION CONTROL
- H11 STORES CONTROL
- H12 PERFORMANCE & EFFICIENCY CALC.
- H13 COMPUTER APPLICATIONS
- H14 PURCHASING

FIGURE 13
SHIPBUILDING ELEMENTS SURVEYED

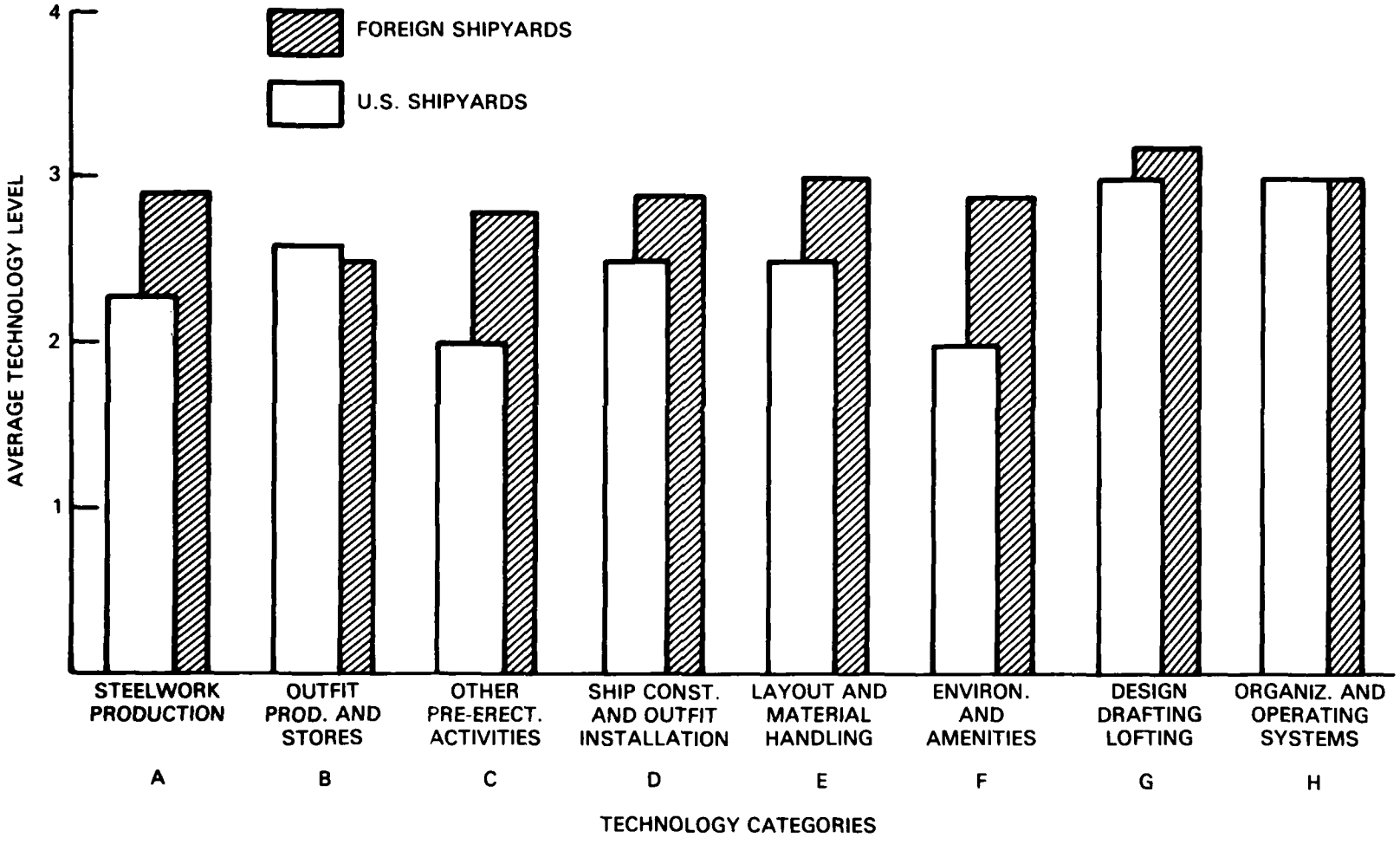


FIGURE 14
TECHNOLOGY LEVELS BY CATEGORY

YEAR	WEEKLY EARNINGS		HOURS WORKED		HOURLY EARNINGS	
	CONTRACT CONSTRUCTION	SHIPBUILDING	CONTRACT CONSTRUCTION	SHIPBUILDING	CONTRACT CONSTRUCTION	SHIPBUILDING
1980	385.44	346.18	37.9	40.3	10.17	8.59
1979	361.76	302.33	38.0	38.5	9.52	7.85
1978	324.85	282.27	36.5	39.7	8.90	7.11
1977	298.19	257.68	36.1	39.4	8.26	6.54
1976	284.56	247.33	37.1	39.7	7.67	6.23
1975	265.35	217.09	36.6	39.4	7.25	5.51
1974	299.68	189.74	38.9	38.1	6.75	4.98
1973	235.69	178.41	37.0	38.7	6.37	4.61
1972	221.51	172.66	36.9	39.6	6.03	4.36
1971	211.67	162.74	37.2	39.5	5.69	4.12
1970	195.45	158.00	37.3	39.9	5.24	3.96

SOURCE: U.S. DEPARTMENT OF LABOR

FIGURE 15
PRODUCTION WORKER WEEKLY EARNINGS, HOURS WORKED, AND HOURLY EARNINGS PER WEEK IN SHIPBUILDING AND CONTRACT CONSTRUCTION, 1970-1980

JOB	TRAINING TIME (IN HOURS)
1. WELDER	8,000
2. SHIPFITTER	8,000
3. MACHINIST	6,000
4. ELECTRICIAN	8,000
5. PIPEFITTER	8,000
6. RIGGER	8,000
7. FLAME CUTTER	2,000
8. CRANE OPERATOR	1,000
9. MARINE DRAFTSMAN	10,000
10. SHIPWRIGHT	8 TO 10 YEARS

SOURCE: NATIONAL ACADEMY OF SCIENCES

FIGURE 16
SELECTED SHIPYARD PRODUCTION JOBS AND ASSOCIATED TRAINING TIMES TO QUALIFY AS FIRST-CLASS JOURNEYMEN

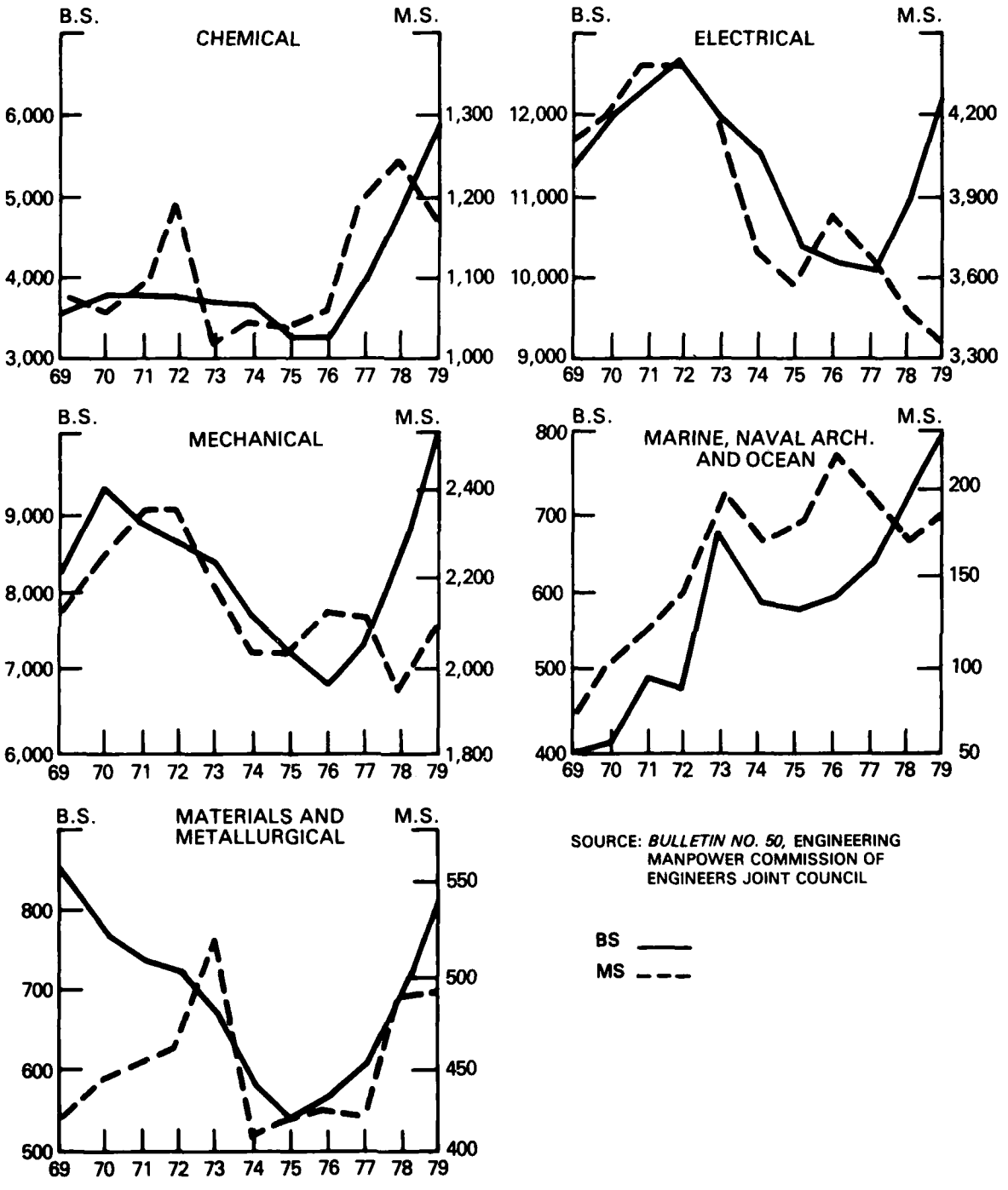


FIGURE 17
ENGINEERING DEGREES AWARDED

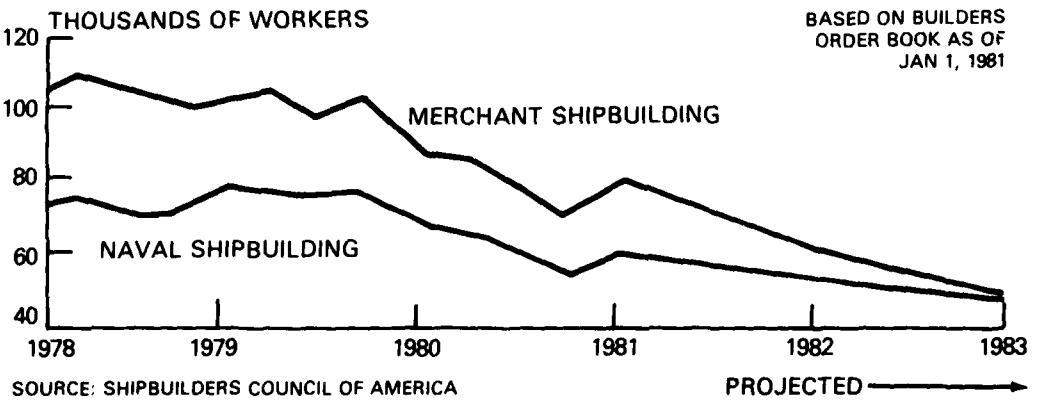
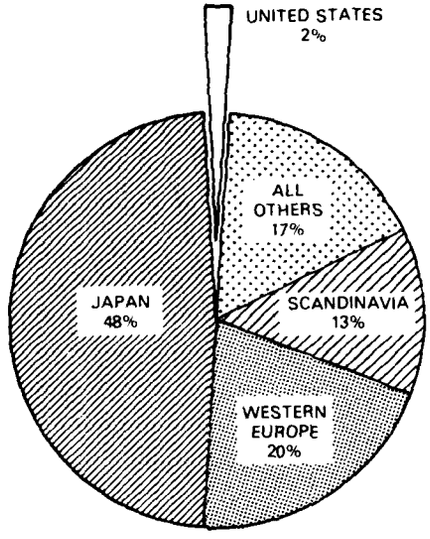
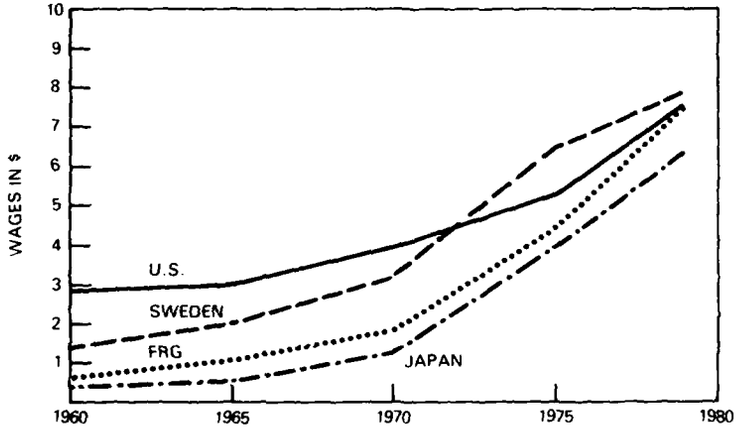


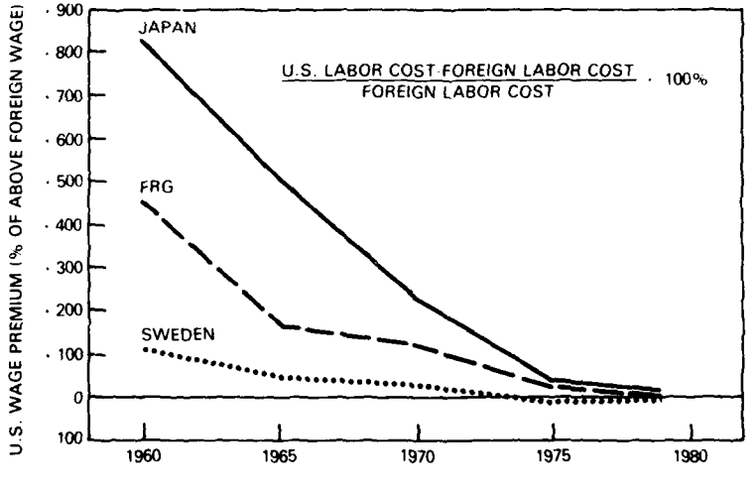
FIGURE 18
SHIPYARD EMPLOYMENT FALLING



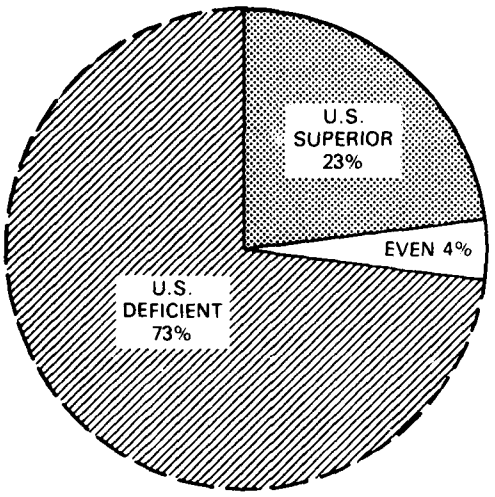
APPENDIX I
MARKET SHARES IN INTERNATIONAL SHIPBUILDING



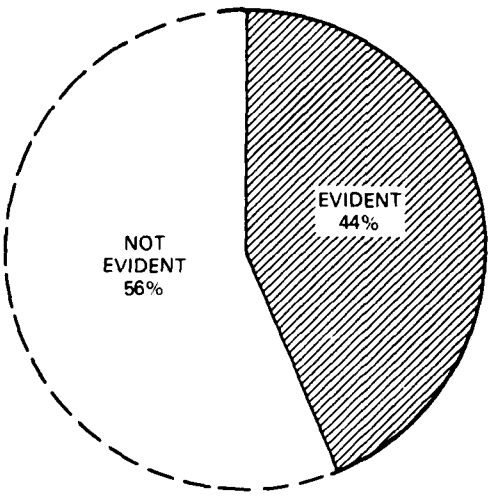
APPENDIX II
AVERAGE HOURLY WAGES IN SELECTED SHIPBUILDING COUNTRIES



APPENDIX III
FOREIGN LABOR COST ADVANTAGES

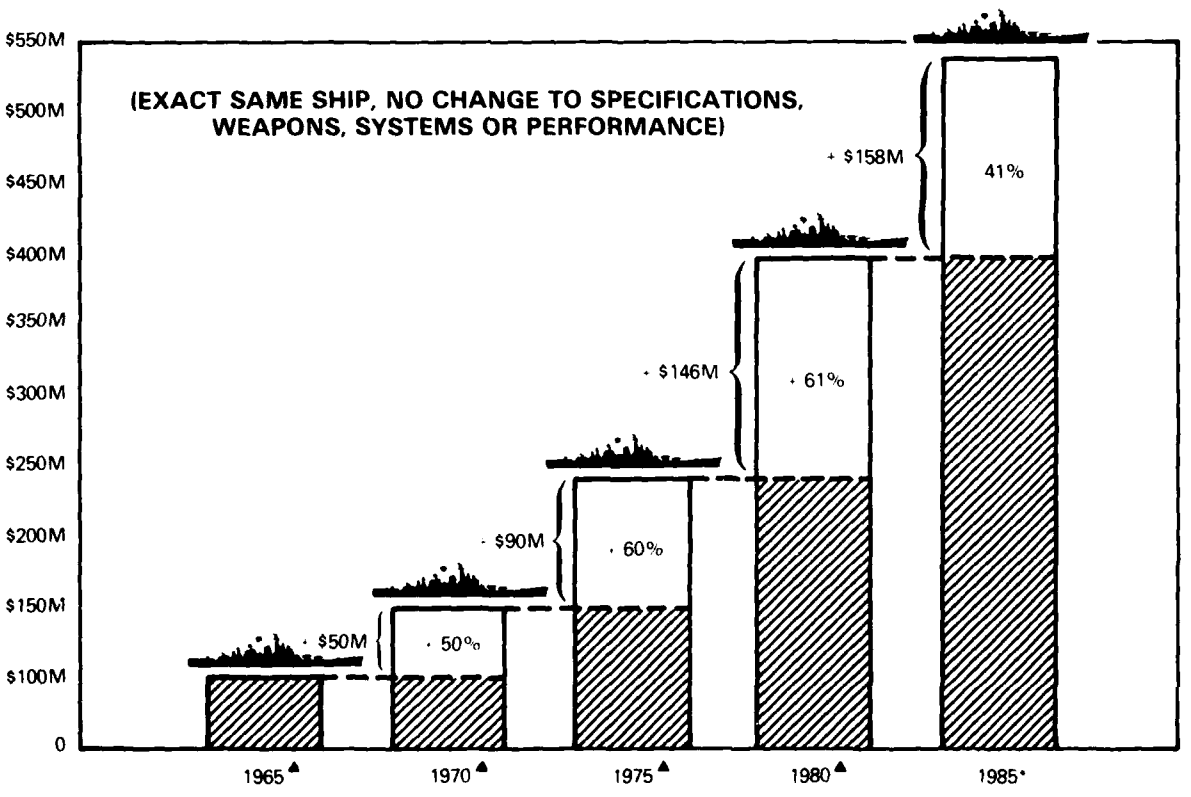


AVERAGE TECHNOLOGICAL LEVEL



"BEST INDUSTRIAL PRACTICE" IN U.S.

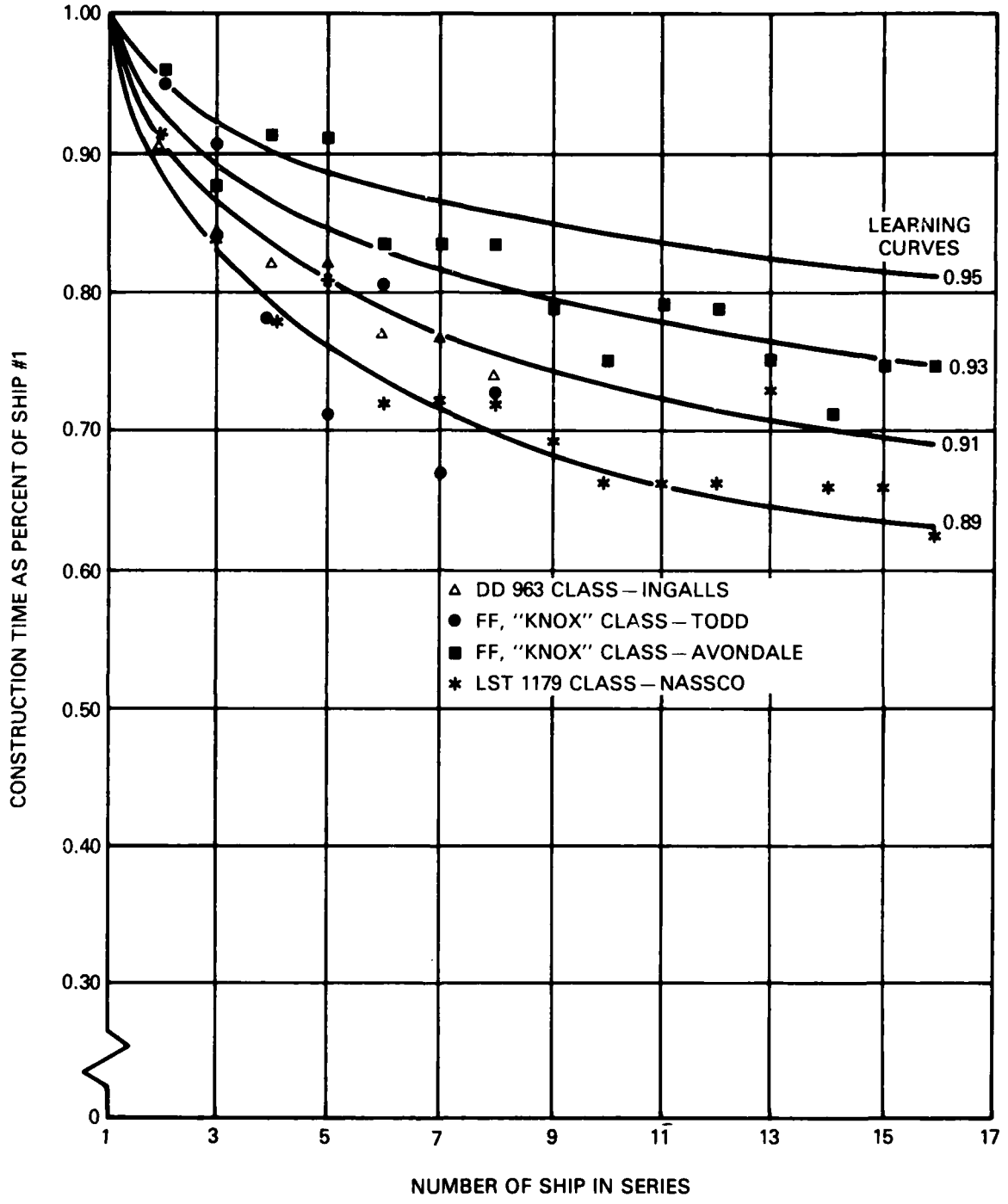
APPENDIX IV
SHIPBUILDING TECHNOLOGY SURVEY RESULTS



▲ DATA BASED ON NAVSEA ESTIMATES

*APPROVED OSD INDICES

APPENDIX V
SHIP PRICE INFLATION



APPENDIX VI
"LEARNING" AS MEASURED IN "TIME TO BUILD"
SHIPS IN SERIES

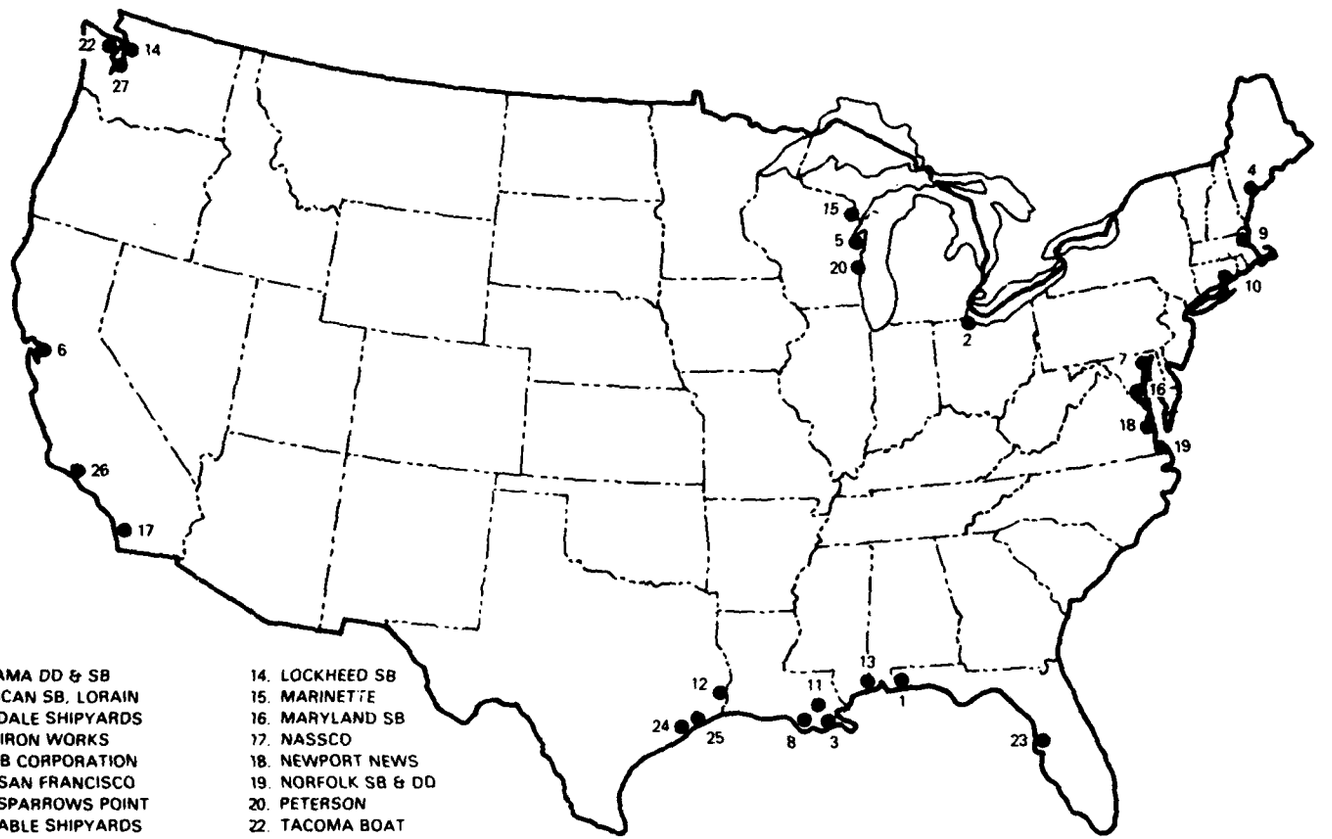
FISCAL YEAR	REPAIRS & ALTERATIONS[1]				CONVERSION[2]				TOTAL REPAIRS ALTERATIONS & CONVERSION			
	NAVAL	PRIVATE	TOTAL	% PRIVATE	NAVAL	PRIVATE	TOTAL	% PRIVATE	NAVAL	PRIVATE	TOTAL	% PRIVATE
1966	511,044	349,619	860,663	40.6	166,100	20,650	186,750	11.1	677,144	370,269	1,047,413	35.4
1967	664,088	352,494	1,016,582	34.7	25,000	121,500	146,500	82.9	689,088	473,994	1,163,082	40.8
1968	667,896	264,106	932,002	28.3	128,900	211,500	340,400	62.1	796,796	475,606	1,272,402	37.4
1969	665,022	235,521	900,543	26.2	131,400	128,700	260,100	49.5	796,422	364,221	1,160,643	31.4
1970	593,331	214,358	807,689	26.5	188,200	149,100	337,300[3]	44.2	781,531	363,458	1,144,990	31.7
1971	686,583	135,118	821,701	16.4	182,800	403,200	586,000[3]	68.8	869,383	538,319	1,407,701	38.2
1972	760,150	176,832	936,982	18.9	226,800	258,500	485,300[3]	50.3	986,950	435,332	1,422,282	30.6
1973	836,630	271,184	1,107,814	24.5	227,500	335,100	562,600[3]	59.6	1,064,130	606,284	1,670,414	36.3
1974	953,793	422,667	1,376,460	30.7	201,200	175,600	376,800[3]	46.6	1,154,993	598,267	1,753,260	34.1
1975	1,124,062	450,960	1,575,022	28.6	127,100	139,000	266,100[3]	52.2	1,251,162	589,960	1,841,122	32.0
1976	1,438,913	621,348	2,060,261	30.2	0	0	0	0	1,438,913	621,348	2,060,261	30.2
197-1	492,113	151,248	643,361	23.5	0	0	0	0	492,113	151,248	643,361	23.5
1977	1,724,821	847,826	2,572,647	33.0	235,500	0	235,500	0	1,960,321	847,826	2,808,147	30.2
1978	1,907,637	952,733	2,860,370	33.3	0	0	0	0	1,907,637	952,733	2,860,370	33.3
1979	1,991,106	983,121	2,974,227	33.1	0	0	0	0	1,991,106	983,121	2,974,227	33.1
1980	2,097,177	1,001,660	3,098,837	32.3	0	0	0	0	2,097,177	1,001,660	3,098,837	32.3

[1] DOES NOT INCLUDE MSC REPAIRS. INCLUDES RDT&E FUNDED SHIPWORK.
[2] PROGRAM VALUE.
[3] EXCLUDES POST DELIVERY AND OUTFITTING INCLUDED IN SHIP COST IN PRIOR YEARS.

SOURCE: NAVSEA 012

ALLOCATION OF NAVAL SHIP REPAIR WORK BETWEEN NAVAL/PRIVATE SHIPYARDS FY 1966-1980 ($000)

APPENDIX VII



1. ALABAMA DD & SB
2. AMERICAN SB, LORAIN
3. AVONDALE SHIPYARDS
4. BATH IRON WORKS
5. BAY SB CORPORATION
6. BETH-SAN FRANCISCO
7. BETH-SPARROWS POINT
8. EQUITABLE SHIPYARDS
9. GEN. DYN.-QUINCY
10. GEN. DYN.-ELEC. BOAT
11. HALTER MARINE
12. LEVINGSTON
13. LITTON INGALLS
14. LOCKHEED SB
15. MARINETTE
16. MARYLAND SB
17. NASSCO
18. NEWPORT NEWS
19. NORFOLK SB & DD
20. PETERSON
22. TACOMA BOAT
23. TAMPA SHIP
24. TODD-GALVESTON
25. TODD-HOUSTON
26. TODD-LOS ANGELES
27. TODD-SEATTLE

APPENDIX VIII
ACTIVE U.S. SHIPBUILDING BASE

JUNE 30, 1981